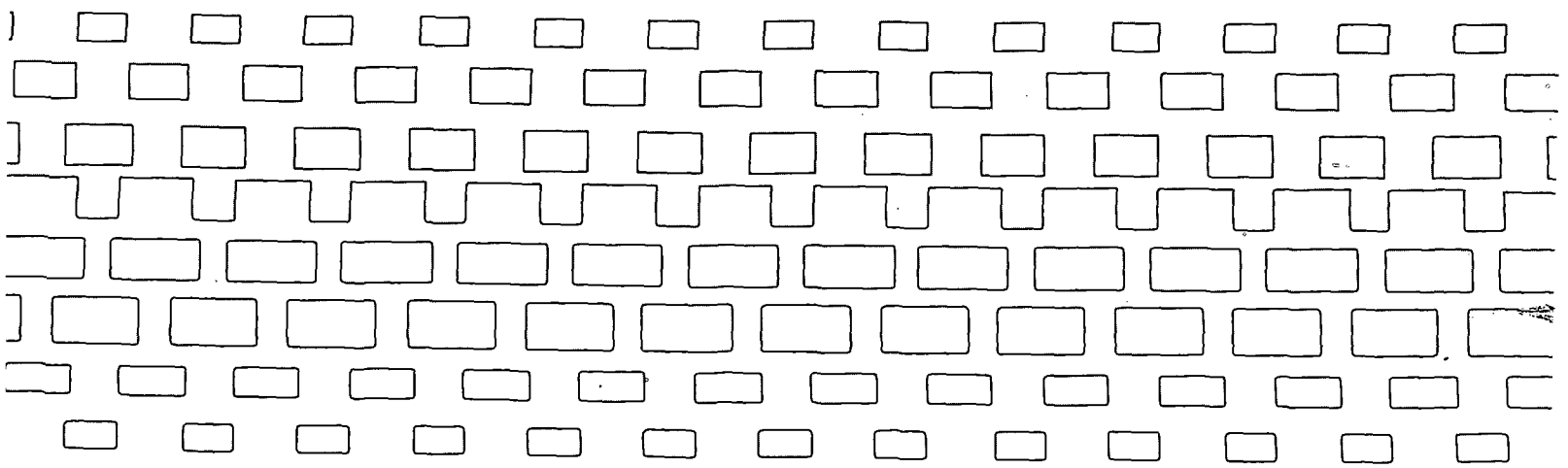
NASA SP–7037 (262)
February 1991

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES



(NASA-SP-7037(262)) AERONAUTICAL ENGINEERING: A CONTINUING BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 262) (NASA) 142 p
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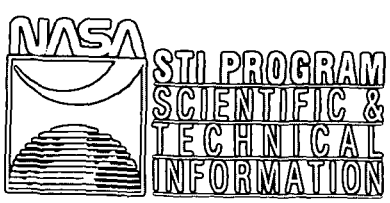

NASA SP-7037 (262)
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AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Program
Washington, DC 1991

INTRODUCTION

This issue of *Aeronautical Engineering—A Continuing Bibliography* (NASA SP-7037) lists 474 reports, journal articles, and other documents originally announced in January 1991 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

Accession numbers cited in this issue are:

STAR (N-10000 Series)	N91-10001 — N91-11665
IAA (A-10000 Series)	A91-10001 — A91-12944

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the publication consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals.

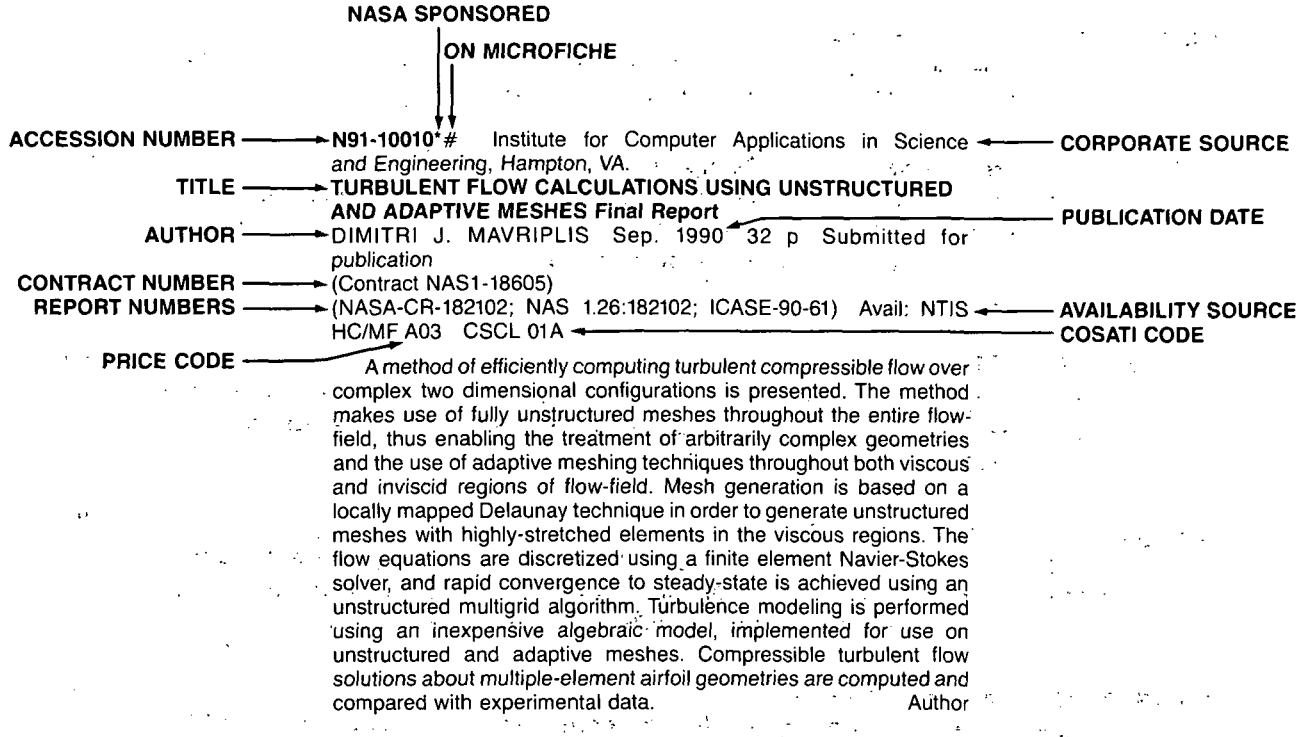
Seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number—are included.

A cumulative index for 1991 will be published in early 1992.

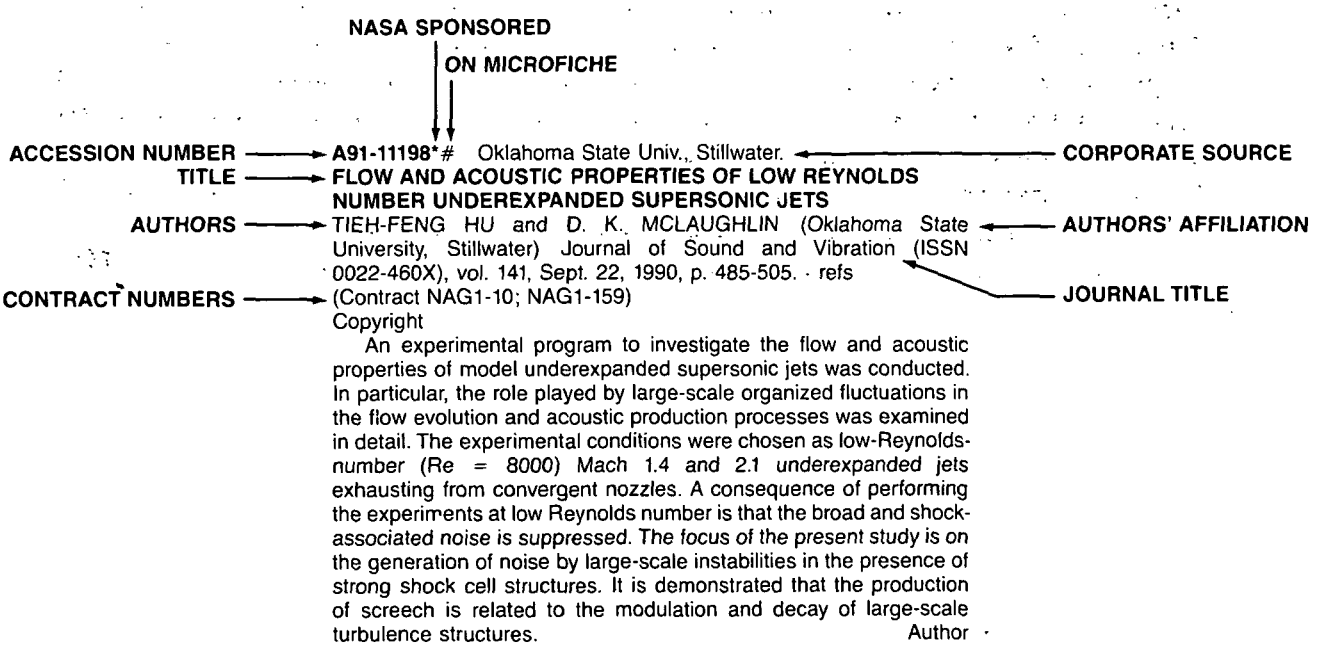
Information on availability of documents listed, addresses of organizations, and NTIS price schedules are located at the back of this issue.

CONTENTS

TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 262)

FEBRUARY 1991

01

AERONAUTICS (GENERAL)

A91-10114#
THE APPLICATION OF COMMERCIAL AIRPLANE AVIONICS TECHNIQUES TO ADVANCED SPACE TRANSPORTATION
MICHAEL RAFTERY and VINCENT A. CALUORI, JR. (Boeing Co., Seattle, WA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3722) Copyright

Operating practices for commercial aircraft are compared with those of partially reuseable space systems. Current commercial regulations for maintaining high levels of safety and dispatch reliably are discussed as they pertain to potential application in a space transportation avionics system. The fundamental manufacturing and operating strategies applied in air and space are compared and the flow through manufacturing, integration, test, and operations for aircraft and spacecraft is presented. It is noted that redundancy is used to protect against failure of critical and essential systems. An example of application of redundant hardware is presented showing the flight critical navigation and air data systems and illustrating several aspects of the flight hardware design. Aircraft computer maintenance programs are discussed, noting that they are developed to take advantage of the extensive onboard test and diagnostic capabilities. L.K.S.

A91-10951
EUROPEAN SYMPOSIUM ON THE FUTURE OF HIGH SPEED AIR TRANSPORT, STRASBOURG, FRANCE, NOV. 6-8, 1989, PROCEEDINGS [SYMPOSIUM EUROPEEN SUR L'AVENIR DU TRANSPORT AERIEN A HAUTE VITESSE, STRASBOURG, FRANCE, NOV. 6-8, 1989, ACTES]
PH. POISSON-QUINTON, ED. (Academie Nationale de l'Air et de l'Espace, Toulouse, France) Symposium organized by Academie Nationale de l'Air et de l'Espace; Sponsored by CEC, Ministere de la Recherche et de la Technologie, Direction Generale de l'Aviation Civile, et al. Toulouse, France, Cepadues-Editions, 1990, 375 p. In French and English. For individual items see A91-10952 to A91-10978.
Copyright

Topics presented include the SST programs in the sixties, NACA/NASA supersonic flight research, Air France experience as a supersonic transport airline, and a NASA view on key technical issues for an advanced high speed commercial transport. Also presented are the sonic boom problem, the advantages and problems of cryogenic fuels for high speed transport, future supersonic transport propulsion optimization, hypersonic transport optimization, the optimization of hybrid propulsion systems, and the need for a hypersonic demonstrator. R.E.P.

A91-10952
SUPERSONIC AIR TRANSPORT PROGRAMS IN THE 60'S [LES PROGRAMMES DE TRANSPORT SUPERSONIQUE DANS LES ANNEES SOIXANTE]
J. FORESTIER, P. LECOMTE, and PH. POISSON-QUINTON (Academie Nationale de l'Air et de l'Espace, Toulouse, France) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 14-29. In French.
Copyright

A review of the SST programs conducted by the United States, France, Great Britain and the USSR during the 1960s is presented. The designs that evolved considered such questions as the supersonic boom and other noise related problems that were directly related to environmental and public opinion issues. Development of the Concorde program is discussed, and a brief outline of the TU 144 project and the discontinued U.S. SST competition is presented. Some aspects of initial Concorde operational problems are also described. R.E.P.

A91-10953* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
NACA/NASA SUPERSONIC FLIGHT RESEARCH
T. G. AYERS (NASA, Flight Research Center, Edwards, CA) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 34-41.
Copyright

The use of experimental and testbed vehicles and their contributions to fundamental problem solving and overall vehicle characteristics are presented. A chronological description of aircraft from the first supersonic flight in the X-1 through the development of the F-100 series, the X-15, and the B-1 is given. One of the early significant contributions made was the development of the all-moving stabilizer that solved the problem associated with high-speed tuck and the trim requirements of entry into the supersonic regime. Some wind tunnel/flight drag characteristics studies associated with the B-1 bomber involving flexibility effects and wind tunnel effects are shown. Finally, the evolution of digital systems to enhance maintainability and reliability and to reduce the work load in the cockpit are described. R.E.P.

A91-10961* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE POTENTIAL FOR A NEW ERA OF SUPERSONIC AND HYPERSONIC AVIATION
ROY V. HARRIS (NASA, Langley Research Center, Hampton, VA) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 100-108. refs
Copyright

A new era of supersonic and hypersonic aviation is envisioned. The potential for supersonic and hypersonic flight vehicles in this new era is analyzed. Technology challenges that must be met in order to bring in this new era of flight are discussed. The current technical status and future potential are cited in the areas of aerodynamics, propulsion, and structural materials. A next major step in the development of high-speed air transportation is suggested. Author

A91-10964
THE SONIC BOOM PROBLEM
A. AURIOL, C. LECOMTE, and C. THERY (ONERA, Chatillon, France) IN: European Symposium on the Future of High Speed

Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 149-154. refs
Copyright

An overview of the sonic boom problem is presented including a description of the physical phenomenon, results on sonic boom effects, and considerations for the aircraft designer. Detailed graphs, descriptions and results of various sonic boom tests are provided. It is shown that the weight and the volume of the aircraft play an important role in the intensity of the boom. The part due to the volume is of particular importance as it deteriorates rapidly with altitude. It is also shown that Mach number (except close to Mach 1) has little influence on the intensity of the boom beneath the flight path. However, it has a considerable effect on the width of the boom path. The most important problem to overcome is the startle effect on humans and intensive research in this area will be required. It is concluded that a diminution of the sonic boom path could be achieved and this would lead to a decrease of supersonic flight restricted areas. R.E.P.

A91-10971
HYPERSONIC AIRCRAFT STUDIES
D. COLLARD (Aerospatiale, Division Avions, Paris, France). IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 251-256.
Copyright

Various aspects of studies being conducted on the design of a hypersonic commercial transport are presented. The baseline configuration comprises a slender wing and sufficient volume to carry cryogenic fuels. It is powered by four turbofan/ramjet combined engines grouped under the rear fuselage, and its cruise performance is deemed satisfactory. However, the off-design performance, considered in a realistic operational and environmental framework, shows it could only operate on a few routes. Structural weight, particularly due to powerplant installation, tends to erode the payload completely. Detailed considerations are also addressed for longitudinal and lateral aerodynamic characteristics, engine installation, low-speed lift/drag ratios, and thermal heating problems. R.E.P.

N91-10001# Office of the Under Secretary of Defense (Acquisitions), Washington, DC.
DOD RESPONSIBILITIES ON FEDERAL AVIATION AND NATIONAL AIRSPACE SYSTEM MATTERS
R. NAKAMURA 22 Jun. 1989 9 p
(PB90-218827; DOD-D-5030.19) Avail: NTIS HC/MF A02
CSCL 01B

The directive reissues Department of Defense (DoD) Directive 5030.19 and supersedes DoD Directive 5030.17. It updates DoD policy and procedures to address peacetime, wartime, and emergency relationships between DoD, DoT, FAA, and other government agencies. The DoD organizational structure is described for interface with the DoT, FAA, and other agencies on air traffic control and airspace matters, NAS matters, joint system acquisitions, and oversight of airlift service provided to the DoD by civil air carriers. DoD policy and planning guidance is provided for comprehensive DoD airspace planning and the relationships between the DoD, DoT, FAA, other government agencies, state governments, and civil communities. Author

02
AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A91-10329#
NUMERICAL SIMULATIONS OF OSCILLATORY COLD FLOWS IN AN AXISYMMETRIC RAMJET COMBUSTOR
SURESH MENON and WEN-HUEI JOU (Quest Integrated, Inc., Kent, WA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 525-534. Previously cited in issue 19, p. 2942, Accession no. A87-44949. refs
(Contract N00014-84-C-0359)
Copyright

A91-10330#
MODES OF OSCILLATION IN A NONREACTING RAMJET COMBUSTOR FLOW
WEN-HUEI JOU and SURESH MENON (Quest Integrated, Inc., Kent, WA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 535-543. Previously cited in issue 19, p. 2942, Accession no. A87-44950. refs
(Contract N00014-84-C-0359)
Copyright

A91-10337#
PERIODIC ROTOR-BLADE AERODYNAMICS INCLUDING LOADING EFFECTS
STEVEN R. MANWARING and SANFORD FLEETER (Purdue University, West Lafayette, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 590-597. Previously cited in issue 20, p. 3347, Accession no. A88-48962. refs
(Contract F49620-88-C-0022)
Copyright

A91-10339*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
OSCILLATING CASCADE AERODYNAMICS BY AN EXPERIMENTAL INFLUENCE COEFFICIENT TECHNIQUE
DANIEL H. BUFFUM (NASA, Lewis Research Center, Cleveland, OH) and SANFORD FLEETER (Purdue University, West Lafayette, IN) *Journal of Propulsion and Power* (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 612-620. Previously cited in issue 03, p. 262, Accession no. A89-14976. refs
Copyright

A91-10340#
STATOR/ROTOR INTERACTION IN A TRANSONIC TURBINE
MICHAEL B. GILES (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 621-627. Research supported by the Rolls-Royce, PLC. Previously cited in issue 23, p. 3758; Accession no. A88-53140. refs
Copyright

A91-11151
THE EFFECTS OF AEROFOIL PROFILE ON WING BUFFET AT LOW SPEEDS
C. A. LUCAS (Australian Artificial Intelligence Institute, Carlton, Australia) and D. J. MAULL (Cambridge, University, England) Aeronautical Journal (ISSN 0001-9240), vol. 94, March 1990, p. 86-90.
Copyright

The unsteady loads on two wings, one exhibiting a trailing edge separation, the other a leading edge separation have been measured. It has been found that there are differences between the two wing loads, one having a large scale viscous-inviscid interaction producing high loads at a low frequency. Author

A91-11157
TRANSONIC BUFFET ON A SUPERCRITICAL AEROFOIL
B. H. K. LEE (National Aeronautical Establishment, Ottawa, Canada) Aeronautical Journal (ISSN 0001-9240), vol. 94, May 1990, p. 143-152. refs
Copyright

The buffet characteristics of a supercritical aerofoil were investigated in the High Reynolds Number Two-Dimensional Test Facility of the National Aeronautical Establishment (NAE). The test was performed quite deep into the buffet regime. The buffet onset boundary was determined from the divergence of the unsteady balance normal force. Steady and unsteady pressure measurements were obtained for shock-induced separation with reattachment as well as fully separated flows. For flow conditions

where discrete shock wave oscillations occurred, ensemble-averaging of the unsteady pressures determined the propagation velocity of the pressure wave induced by periodic shock motion. A model of the self-sustained oscillatory shock motion due to shock-boundary layer interaction was formulated. Broad-band cross-correlations of the pressure field determined the downstream convection velocities of the turbulent eddies of separated flows. Author

A91-11159
THE AERODYNAMIC INTERFERENCE BETWEEN TANKER AND RECEIVER AIRCRAFT DURING AIR-TO-AIR REFUELLING
A. W. BLOY and V. TROCHALIDIS (Manchester, Victoria University, England) Aeronautical Journal (ISSN 0001-9240), vol. 94, May 1990, p. 165-171. Research supported by SERC and Ministry of Defence. refs
Copyright

Wind tunnel data from a tanker wing and receiver aircraft model at varying vertical separation have been compared with theoretical results. In the aerodynamic model the tanker wing is represented by a horseshoe vortex while the aerodynamic loads on the receiver are determined by the vortex lattice method and lifting-line theory, although an approximate method is used to determine the side force on the fin. In the longitudinal case, data were obtained for low, mid and high tailplane positions and, with the exception of the pitching moment results, fairly good agreement is obtained between theory and experiment. The lateral aerodynamic interference was determined by banking the tanker wing and displacing it sideways and by yawing the receiver model. Fairly good agreement is obtained between the theory and experiment for the most significant terms which are the rolling moments due to bank and sideways displacement. The effect of the sidewash due to the tanker wake on the receiver in yaw is found to be relatively insignificant. Over the range of bank, yaw and sideways displacements tested, the results are almost linear. Author

A91-11160
SOLUTION OF THE EULER EQUATIONS ON UNSTRUCTURED GRIDS FOR TWO-DIMENSIONAL COMPRESSIBLE FLOW
L. STOLCIS and L. J. JOHNSTON (Von Karman Institute for Fluid Dynamics, Rhode-Saint-Genese, Belgium) Aeronautical Journal (ISSN 0001-9240), vol. 94, June-July 1990, p. 181-195. refs
Copyright

A method for the numerical solution of the two-dimensional Euler equations on unstructured grids has been developed. The cell-centered symmetric finite-volume spatial discretization is applied in a general formulation that allows the use of arbitrary polygonal computational cells. The integration in time, to a steady-state solution, is performed using an explicit, multi-stage procedure, with standard convergence acceleration techniques such as local time stepping, enthalpy damping and implicit residual smoothing. Accuracy of solution, in terms of minimizing spurious entropy production, is achieved through careful treatment of the artificial dissipative terms near boundaries. Standard test cases for both subcritical and supercritical flows, including single- and multi-element aerofoils have been used to validate the method. Author

A91-11162
CONTROL OF VORTICAL SEPARATION ON A CIRCULAR CONE
N. J. MOURTOS (San Jose State University, CA) Aeronautical Journal (ISSN 0001-9240), vol. 94, June-July 1990, p. 213-219. refs
Copyright

A theoretical model for the analysis of the flow around conical bodies at moderate angles of attacks is discussed. A single line-vortex model is initially used to compute the outer inviscid field for specified separation lines; a 3-D boundary layer is represented by a momentum equation for the cross-flow, analogous to that for a plane boundary layer, and a von Karman/Pohlhausen approximation is applied to solve the equation. The cross-flow separation for both laminar and turbulent layers is determined by matching the pressure at the upper and lower separation points. This iterative procedure yields a solution for the separation lines, the positions of the vortices, and the vortex lift of the body. Control of separation is achieved by blowing tangentially from slots located symmetrically along the cone generators. B.P.

A91-11198* Oklahoma State Univ., Stillwater.
FLOW AND ACOUSTIC PROPERTIES OF LOW REYNOLDS NUMBER UNDEREXPANDED SUPERSONIC JETS
TIEH-FENG HU and D. K. MCLAUGHLIN (Oklahoma State University, Stillwater) Journal of Sound and Vibration (ISSN 0022-460X), vol. 141, Sept. 22, 1990, p. 485-505. refs
(Contract NAG1-10; NAG1-159)
Copyright

An experimental program to investigate the flow and acoustic properties of model underexpanded supersonic jets was conducted. In particular, the role played by large-scale organized fluctuations in the flow evolution and acoustic production processes was examined in detail. The experimental conditions were chosen as low-Reynolds-number (Re = 8000) Mach 1.4 and 2.1 underexpanded jets exhausting from convergent nozzles. A consequence of performing the experiments at low Reynolds number is that the broadband shock-associated noise is suppressed. The focus of the present study is on the generation of noise by large-scale instabilities in the presence of strong shock cell structures. It is demonstrated that the production of screech is related to the modulation and decay of large-scale turbulence structures. Author

A91-11347
APPLICATION OF THE VORTEX CLOUD METHOD TO CASCADES
R. I. LEWIS International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 3-4, 1989, p. 231-245. refs
Copyright

The vortex cloud method for modeling the Navier-Stokes equations in two-dimensional flow is extended to the simulation of viscous flow through turbine or compressor cascades. For a turbine cascade, the predicted surface pressure agrees well with the experimental values, but losses are overpredicted. In the case of a compressor cascade, problems arise due to the onset of premature stall for diffusing flows. A hybrid method is proposed which alleviates this problem through the introduction of potential flow restrictions to the suction surface. V.L.

A91-11701#
BASIC HELICOPTER AERODYNAMICS
J. SEDDON Washington, DC/London, England, American Institute of Aeronautics and Astronautics/Blackwell Scientific Publications, 1990, 154 p. refs
Copyright

The basic principles of helicopter design are examined in a brief introduction for engineering students. Chapters are devoted to momentum theory and wake analysis for a rotor in vertical flight; blade element theory; rotor mechanisms and rotor aerodynamics for forward flight; aerodynamic design; performance; trim, stability, and control. Diagrams, graphs, and photographs are provided. T.K.

A91-11755#
COMPARISON OF DIFFERENT CALCULATION METHODS AS APPLIED TO A FUSELAGE OF LENTICULAR SECTION [COMPARAISON DE DIFFERENTES METHODES DE CALCUL APPLIQUEES A UN FUSELAGE DE SECTION LENTICULAIRE]
P. D'ESPINEY (ONERA, Chatillon, France) (NATO, AGARD, Symposium on Missiles Aerodynamics, Friedrichshafen, Federal Republic of Germany, Apr. 23-26, 1990) ONERA, TP no. 1990-66, 1990, 16 p. In French. refs
(ONERA, TP NO. 1990-66)

Measurements from wind tunnel tests conducted on a noncircular body representative of nonconventional missile shapes are analyzed. Mach numbers from 0.4 to 4.5 at angles of attack

up to 20 degrees with sideslip angles up to 10 degrees were studied. The data base consists of wall static pressure measurements and also of flowfield measurements at Mach 2 for angles of attack of 10 and 20 degrees. Comparisons between experimental data and calculations obtained with different codes are presented, discussing the advantages and drawbacks as to accuracy and time cost. R.E.P.

A91-11777#
DETAILED MEASUREMENTS OF THE FLOW FIELD AT THE OUTLET OF A BACKSWEPT TRANSONIC CENTRIFUGAL IMPELLER EQUIPPED WITH A VANED DIFFUSER
CH. FRADIN and G. JANSSENS (ONERA, Chatillon, France) ONERA, TP no. 1990-101, 1990, 7 p. refs
(ONERA, TP NO. 1990-101)

Two-focus laser velocimetry is presently used to study the flow field development at the impeller outlet of a transonic-flow centrifugal compressor whose impeller incorporates splitter blades and an advanced, backswept blade geometry, while the vaned diffuser employs curved vanes. Velocity profiles and angles are obtained for different relative locations of impeller blades and diffuser vanes. Due to the high flow distortion in the impeller and in the blade passages, highly unsteady flow angle and Mach number fluctuations emerge in both the axial and blade-to-blade directions; these fluctuations also arise, with comparable amplitudes, in the vaned diffuser throat. O.C.

A91-11779#
DETERMINATION OF KINETIC HEATING ON WIND TUNNEL MODELS BY THE SURFACE TEMPERATURE METHOD [DETERMINATION DES ECHAUFFEMENTS CINETIQUES SUR MAQUETTES EN SOUFFLERIES PAR LA METHODE DES TEMPERATURES SUPERFICIELLES]
H. CONSIGNY and Y. LE SANT (ONERA, Chatillon, France) (Journees d'Etudes sur les Mesures de Temperatures, Paris, France, June 19, 20, 1990) ONERA, TP no. 1990-104, 1990, 26 p. In French. refs
(ONERA, TP NO. 1990-104)

A review is presented of the surface temperature method used to measure kinetic heating on wind tunnel models. The specific instrumentation used and the techniques employed to obtain these measurements are described. These methods permit the analysis of the effects of thickness, curvature and thermal characteristics. Particular attention is given to recently developed methodology for determining thermal characteristics and to the modeling of the sensor units using a two-dimensional finite element code. It is shown that the effect of lateral conduction can be significant. R.E.P.

A91-11782#
ESTIMATION OF THE TURBULENT SPECTRAL DENSITIES OF THE MASS-DENSITY USING TWO-DIMENSIONAL FOURIER TRANSFORM OF DIGITIZED SCHLIEREN PICTURES
R. DERON and J. P. FALENI (ONERA, Chatillon, France) (European Turbulence Conference, 3rd, Stockholm, Sweden, July 3-6, 1990) ONERA, TP no. 1990-110, 1990, 9 p. refs
(ONERA, TP NO. 1990-110)

The analysis of quantitatively digitized schlieren photographs according to a two-dimensional Fourier space approach is shown to result in a method furnishing two-dimensional calibrated cross-sections of three-dimensional mass-density spectral densities. Turbulent aerodynamic flow images have been thus obtained in wind tunnel experiments, using the single-beam z-shaped schlieren technique. While the -11/3 Kolmogorov power law is obtained in a transverse direction to the mean flow, discrepancies from the law appear in other directions. Also determined are rms data for spectral mass density fluctuations and for the outer scale of the turbulence. O.C.

A91-11831#
A STUDY OF IMPLICIT SPACE-MARCHING METHOD FOR THE SUPERSONIC VISCOUS FLOW OVER THE BLUNT CONE
HANXIN ZHANG, HUI YAO, SHUCHUN GAO, and QING SHEN (China Aerodynamics Research and Development Centre, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 235-246. In Chinese, with abstract in English. refs

A new technique for handling the pressure gradient in the streamwise momentum equation of parabolized Navier-Stokes equations has been developed in order to compute the supersonic viscous flow over bodies using a noniterative, implicit, space-marching finite difference method. The stability conditions for the method are derived from model equations using a new technique. Stable space-marching schemes without a minimum allowable step size are given and used to compute supersonic flow over an axisymmetric blunt cone. The results are compared with those from conventional marching methods using other techniques for treating the streamwise pressure gradient term. The present technique exhibits superior capabilities for accurate and stable calculations. C.D.

A91-11836#
A STUDY OF CYLINDRICAL INTERACTION OF TURBULENT BOUNDARY LAYER/SHOCK WITH SWEPT COMPRESSION CORNERS
XUEYING DENG and ZHIZHONG LIU (Beijing University of Aeronautics and Astronautics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 280-285. In Chinese, with abstract in English. refs

The three-dimensional shock wave and turbulent boundary layer interaction with swept compression corners is experimentally studied. The swept angles range from 0 to 60 deg and the streamwise corner angles from 10 to 30 deg. Freestream Mach numbers of 1.79, 2.04, and 2.50 are used with Reynolds numbers of (2.42-2.47) x 10 to the 7th/m. The results indicate the existence of cylindrical and conical flow regimes in the interactions over the given Mach number range. The boundary of the cylindrical/conical regime occurs at higher alpha(s), gamma value with increasing free-stream Mach number. The upstream influence length in the cylindrical regime can be correlated with that of the two-dimensional compression corner. The Mach number effect and crossflow effect on this correlation are examined. C.D.

A91-11838#
FINITE ELEMENT METHOD FOR COMPUTATION OF TRANSONIC FLOW ABOUT WINGS FROM THE PRESSURE MINIMUM INTEGRAL
YIZHAO WU and ZUOSHENG YANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 293-300. In Chinese, with abstract in English. refs

Starting with the full potential equation, a finite-element method for computing transonic flow about wings is given, using the pressure minimum integral. FORTRAN programs are worked out. A mesh generation technique, which is suitable for the FEM, is presented. The SLOR method and the successive division method are employed. Numerical results for an M6 wing and a delta wing are given. Author

A91-11839#
AN EFFICIENT METHOD FOR SOLVING TRANSONIC FLOW ABOUT PLANE CASCADES WITH A LARGE NOSING
QIUSHENG LIU and MENGYU SHEN (Tsinghua University, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 301-307. In Chinese, with abstract in English. refs

This paper proposes an efficient numerical method predicting exactly the pressure distribution on the blade surfaces, especially in the nosing region. Reforming the aerodynamic equations from an arbitrary normal curve coordinate system into that of von Mises, the streamline governing equation is obtained and solved efficiently in a quasi-boundary-layer coordinate system with a line-relaxation method. The numerical results for RA blades agree well with the experiment and show that, among all the methods known, the present one has the best accuracy and takes the least CPU time. Author

A91-11840#
CALCULATION OF BOUNDARY-LAYER FLOWS ON LOW REYNOLDS NUMBER AND TRANSONIC AIRFOILS
QIN E (Northwestern Polytechnical University, Xian, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 308-314. In Chinese, with abstract in English. refs

In this paper, the laminar and turbulent boundary-layer flows on transonic and low-Reynolds-number airfoils are calculated using a compressible-momentum and mean-flow kinetic-energy inverse-integral boundary-layer equation method. A transition prediction formulation of the e exp 9 type is employed to evaluate the location of transition with laminar separation bubbles, and an extra lag equation is included in the turbulent formulation to account for lags in the response of the turbulent stresses. Good agreement with experiment is obtained. Author

A91-11841#
A THREE-DIMENSIONAL INCOMPRESSIBLE EULER FLOW SOLUTION IN TURBOMACHINERY
YAONAN HUA (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 315-320. In Chinese, with abstract in English. refs

Using an ADI scheme to solve the Euler equation of primitive variables, the three-dimensional incompressible flowfield in turbomachinery is solved. After the pseudocompressibility is introduced in the continuity equation, the system of governing equations is changed from undefined type into hyperbolic type. Giving initial values and boundary conditions, the system of equations can be solved by use of a time-marching method to get a stable solution. The three-dimensional flowfield within the rotor of a single-stage axial compressor is calculated. The prediction results agree with experimental data. Author

A91-11843#
VORTEX DEVELOPMENT ON CRUCIFORM CANARD CONFIGURATIONS AT SUPERSONIC SPEEDS
JINSEN HONG (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 327-334. In Chinese, with abstract in English. refs

The vapor-screen technique was used at supersonic speeds to determine the development of the longitudinal vortices. Four vortices originating from the trailing edge of canard fins, which tend to 'leapfrog' in a crossflow plane, or two vortices of the dihedral fins and a pair of symmetric body vortices, which tend to 'hybrid leapfrog' in another crossflow plane, could be observed. Phenomena of vortex unstability appeared when vortices approached the leapfrog distance. Predicted vortex trajectories based on slender-body theory were also compared to the experimental data. The mathematical model predicted the paths of the individual vortices that developed over the missile, provided their initial locations and relative strengths were appropriately specified. Author

A91-11844#
THE CALCULATION METHOD FOR SUBSONIC LONGITUDINAL AND LATERAL AERODYNAMIC CHARACTERISTICS OF COMPLETE AIRCRAFT CONFIGURATION
MINGSHENG MA and QIDE YANG (China Aerodynamics Research and Development Centre, Mianyang, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 335-338. In Chinese, with abstract in English.

This paper presents a vortex-lattice method which is suitable for the calculation of subsonic longitudinal and lateral aerodynamic characteristics of aircraft. In the method, the lifting surface is simulated by a single vortex-lattice layer arranged on the average surface of the wing mean-camber surface, or by a double vortex-lattice layer arranged on the average surfaces of the upper surface and the lower surface of the wing. The body is simulated by quadrangular vortex rings arranged on the surface, or by a vortex grid arranged on a series of concentric multiangular cylindrical surfaces. The ground effect is simulated by an image-vortex system. The effect of wing-wake vortex deflection on horizontal tail and vertical tail is discussed. Comparison with other theoretical and experimental results confirms that the method has enough accuracy for engineering applications. Author

A91-11845#
AN APPROXIMATE CALCULATING METHOD OF SUPERSONIC/HYPERSONIC UNSTEADY AERODYNAMIC FORCES OF AIRFOILS
JINGSONG CHEN and JUN CAO (Nanjing Aeronautical Institute, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 339-344. In Chinese, with abstract in English. refs

A local-flow piston theory is described. Using this theory, formulas are developed which are used for calculating pressure distributions and oscillating derivatives of airfoils in supersonic/hypersonic flow. The numerical results are compared with experimental data and the results of other theories. It is shown from the examples that, although the piston theory is not valid for cases with M delta(max) greater than 1, the method based on local-flow piston theory can still give reasonable results. Author

A91-11848#
APPLICATION OF LU-ADI ALGORITHM IN TWO-DIMENSION TRANSONIC FLOW
FENG LI and YIYUN WANG (Beijing Institute of Aerodynamics, People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 8, Sept. 1990, p. 358-362. In Chinese, with abstract in English.

A91-11900#
LOW MACH NUMBER EULER COMPUTATIONS
D. W. ZINGG (Toronto, University, Downsview, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 36, Sept. 1990, p. 146-152. refs

Numerical solutions of the Euler equations for two-dimensional airfoil flows at low Mach numbers are compared with analytical solutions for incompressible potential flow. The Euler solutions were obtained using the computer code ARC2D, which employs the Beam and Warming implicit approximate factorization algorithm in generalized co-ordinates. Analytical solutions for incompressible potential flow were calculated through Karman-Trefftz transformations. Effects of free-stream Mach number, artificial dissipation, and grid clustering are presented. At a free-stream Mach number of 0.05, the numerical results obtained using a 249 by 49 grid show excellent agreement with the analytical solutions. Author

A91-11909
A THREE-DIMENSIONAL BOUNDARY LAYER ON BODIES WITH A SLIGHT CROSS-SECTIONAL ASYMMETRY AT SMALL ANGLES OF ATTACK [PROSTRANSTVENNYI POGRANICHNYI SLOI NA TELAKH S MALOI ASIMMETRIEI POPERECHNOGO SECHENIIA PRI NEBOL'SHIKH UGLAKH ATAKI]
A. D. KHON'KIN and V. I. SHALAEV Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 313, no. 5, 1990, p. 1067-1071. In Russian. refs

Equations of a three-dimensional boundary layer are analyzed asymptotically in a rigorous manner, including linear (with respect to cross-sectional asymmetry and angles of attack) effects. It is shown that, in this case, the problem is reduced to that of solving a set of two-dimensional problems. Singular solutions are obtained for the equations of flow which are valid in the vicinity of sharp and blunt apexes. The results of the study make it possible to significantly simplify the calculation of the boundary layer on the fuselage under cruising flight conditions. V.L.

A91-12014
AN EXPERIMENTAL STUDY OF THE LAMINAR-TURBULENT TRANSITION BEHIND THREE-DIMENSIONAL ROUGHNESS IN A BOUNDARY LAYER ON A SHARP CONE [EKSPERIMENTAL'NOE ISSLEDOVANIE LAMINARNO-TURBULENTNOGO PEREKHODA ZA TREKHMERNOI NEROVNOST'IU V POGRANICHNOM SLOE NA OSTROM KONUSE]
A. S. SKURATOV and A. V. FEDOROV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 60-66. In Russian. refs
Copyright
The laminar-turbulent transition behind three-dimensional surface roughness in a nongradient boundary layer is investigated for a high supersonic velocity of the incoming flow with emphasis on the qualitative characteristics of the transition. Quantitative data on the heat transfer coefficient distribution near the roughness and in its wake are determined. Data on the position of the laminar-turbulent transition are compared against the correlations used in practice. V.L.

A91-12016
EFFECT OF ENERGY RELEASE IN THE SHOCK LAYER ON SUPERSONIC FLIGHT [VLIIANIE ENERGOVYDELENIIA V UDARNOM SLOE NA SVERKHZVUKOVOI POLET]
S. I. ARAFAILOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 142-151. In Russian. refs
Copyright
Supersonic flow past an extended axisymmetric body is investigated analytically for the case where an energy release region is present between the body surface and the shock wave. Such regions can be used to change the aerodynamic characteristics of flying bodies and to influence the flight through a decrease or an increase in the drag coefficient or through the generation of an additional lifting force or an aerodynamic moment. Here, a simple model of stationary flow past a body with an energy release source is used to determine the energy source parameters corresponding to a maximum control (lift) force per unit time for a given energy consumption rate. V.L.

A91-12017
SHOCK WAVE FORMATION DURING INTERACTION WITH A WEAK DISCONTINUITY AT THE BOUNDARY OF A LOCAL SUBSONIC REGION [FORMIROVANIE UDARNOI VOLNY PRI VZAIMODEISTVII SO SLABYM RAZRYVOM NA GRANITSE MESTNOI DOZVUKOVOI ZONY]
S. A. SHCHERBAKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 152-158. In Russian. refs
Copyright
For the Tricomi equation of plane potential flow in velocity hodograph variables, a self-similar solution is obtained which explains the formation of a shock wave of the strong family (the Mach number behind the wave is less than 1) at the sonic line. The intensity of the shock wave varies along its generatrix in accordance with a power law with an exponent close to one. At the interaction point, the discontinuity of the derivatives along the flow lines equals infinity. V.L.

A91-12018
INTERACTION OF TWO SUPERSONIC RADIAL GAS FLOWS [VZAIMODEISTVIE DVUKH SVERKHZVUKOVYKH RADIAL'NYKH POTOKOV GAZA]
M. G. LEBEDEV and A. V. MIASNIKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 159-165. In Russian. refs
Copyright
The flow resulting from the impact of two spherically symmetric supersonic gas flows generated by three-dimensional sources is investigated using a nonviscous ideal gas model. In the case where the characteristics of both sources are the same, the problem is reduced to that of the interaction between a spherically symmetric flow and a plane obstacle. For a certain limiting process, flow from one of the sources can be reduced to a uniform supersonic gas flow. In this case, the problem is reduced to that of uniform gas flow around a source. Astrophysical applications of the problem are briefly discussed. V.L.

A91-12019
FLUCTUATIONS OF A SHOCK WAVE GENERATED BY BOUNDARY LAYER SEPARATION [O KOLEBANIIAKH SKACHKA UPLOTNENIIA, INDUTSIROVANNOGO OTRYVOM POGRANICHNOGO SLOIA]
V. N. BIBKO, B. M. EFIMTSOV, V. G. KORKACH, and V. B. KUZNETSOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 168-170. In Russian.
Copyright
The mechanisms of shock wave fluctuations induced by separation in supersonic flow past a forward-facing step were investigated experimentally by measuring the spatial correlations of wall pressure pulsations in a low-noise wind tunnel for Mach 2.0 and 4.0. An analysis of the results obtained indicates that turbulent pulsations of the unperturbed boundary layer have little effect on the fluctuations of the separation-induced shock wave. From a more general standpoint, the experimental results provide additional evidence for the self-organization of separated flows, which is observed in this particular case as a certain behavior of the nonstationary flow characteristics. V.L.

A91-12020
FLOW OF A RAREFIED GAS AROUND A SPHERE IN THE PRESENCE OF INJECTION [OBTEKANIE SFERY RAZREZHENNYM GAZOM PRI NALICHII VDUVA]
K. V. NIKOLAEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), July-Aug. 1990, p. 175-179. In Russian. refs
Copyright
Hypersonic flow of a rarefied gas past the windward side of a sphere, with distributed injection from its surface, is investigated using direct statistical modeling by the Monte Carlo method. It is shown, in particular, that gas injection from the sphere surface can be used to reduce both the heat flow and the body resistance for Reynolds numbers greater than 1. The efficiency of injection increases with the Reynolds number, in agreement with results based on the continuum theory. V.L.

A91-12226#
AERODYNAMIC HEATING IN THE INTERACTION REGIONS OF SHOCK WAVES AND TURBULENT BOUNDARY LAYERS INDUCED BY SWEPTBACK BLUNT FINS
SHIGERU ASO (Kyushu University, Fukuoka, Japan), KURANAGA SEISHI (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan), and SHIGEHIDE NAKAO Kyushu University, Faculty of Engineering, Memoirs (ISSN 0023-6160), vol. 50, June 1990, p. 121-134. refs
Aerodynamic heating phenomena in three-dimensional boundary layers are discussed. The experimental conditions include sweptback blunt fins, a thin-film heat-transfer gage with high spatial resolution and fast response, Mach number of 4, wall temperature ratio (Tw/To) of 0.65, and Reynolds number of 1.2 x 10 to the 7th. Blunt fins having semicylindrical leading edges and sweep angles of 0, 15, 30, and 45 deg are tested, and the flow around them is made visible using oil techniques. The surface pressure and heat flux distributions in the interaction regions of the shock waves and the turbulent boundary layers have two peaks at smaller sweep angles and one peak at larger angles, respectively. With the increase of the sweep angle of the fin, the size of the interaction region decreases, the maximum peak pressure and the heating rate decrease to an even greater extent, and the shock structure becomes simpler and stable. B.P.

A91-12434#
NUMERICAL SIMULATION OF VORTEX-WEDGE INTERACTION
DUCK-JOO LEE (Korea Advanced Institute of Science and

Technology, Seoul, Republic of Korea), YOUNG-NAM KIM, and JIN-HO PARK AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-3918)

Interaction between vortical flows and a solid surface is one of the primary sources of noise and unsteady loading. The mechanism of the interaction is studied numerically for a single Rankine vortex impinging on a wedge. An Euler-Lagrangian method is employed to calculate the unsteady incompressible viscous flows in two dimensions. A hybrid vortex sheet and a random vortex method are used to describe the vorticity fields. The flows away from the wedge surface and near the surface are modeled as vortex blobs and vortex sheets, respectively. Vortex trajectories are presented at selected times for both the inviscid and the viscous interactions. The incident vortex distorts and splits when the vortex nears the wedge, and a secondary vortex is shed near the leading edge of the wedge. Author

A91-12472#
NUMERICAL SIMULATION OF 3-D SUPERSONIC FREE SHEAR LAYERS
I. TUNCER and L. N. SANKAR (Georgia Institute of Technology, Atlanta) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 13 p. refs
(Contract N00014-89-J-1319)
(AIAA PAPER 90-3958) Copyright

The temporal stability and growth characteristics of three-dimensional supersonic shear layers are numerically investigated. An explicit time marching scheme that is second order accurate in time and fourth order accurate in space is used to study this problem. The shear layer is excited by random initial disturbances or instability waves computed from a linear stability analysis. It is observed that the temporal growth is a strong function of the convective Mach number of the eddies. At low convective Mach numbers organized spanwise structures develop both for the random disturbance and the modal disturbance cases. At superosnic convective Mach numbers, vortical structures with significant streamwise components were found to occur. Author

A91-12473*# Sandia National Labs., Albuquerque, NM.
INSTABILITY OF A SUPERSONIC SHOCK-FREE ELLIPTIC JET
ROY S. BATY (Sandia National Laboratories, Albuquerque, NM), JOHN M. SEINER, and MICHAEL K. PONTON (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 15 p. refs
(Contract NAG1-657)
(AIAA PAPER 90-3959)

A comparison of the measured and the computed spatial stability properties of an aspect ratio 2, supersonic, shock free, elliptic jet is presented. The shock free nature of the elliptic jet furnishes a perfect test of the validity of modeling the large scale coherent structures in the initial mixing region of noncircular supersonic jets with the linear hydrodynamic stability theory. Aerodynamic and acoustic data are measured to compute the mean velocity profiles and to provide a description of the spatial composition of pressure waves in the elliptic jet. The measured mean velocity profiles are employed to provide a qualitative model for the cross sectional geometry and the smooth velocity profiles utilized in the stability analysis. It is shown that the measured frequency associated with peak amplitude noise radiation agrees with that frequency predicted to dominate the large scale structure near the end of the potential core. R.E.P.

A91-12489*# North Carolina State Univ., Raleigh.
INTERACTION BETWEEN ROTORS OF A COUNTER ROTATING PROPELLER
JIN-DEOG CHUNG, JOSEPH HOUGH, and ROBERT T. NAGEL (North Carolina State University, Raleigh) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. Research supported by McDonnell Douglas Corp. refs
(Contract NAG3-855)
(AIAA PAPER 90-3976) Copyright

Thermal anemometer measurements were obtained from a stationary hot film probe mounted between the forward and aft rotors of a model CRP. Data were obtained at several locations between rotors. To establish the rotor-rotor interaction flow mechanism, a method of conditional sampling has been developed which effectively fixes the forward rotor position in time or space and permits averaging the mean wake at any fixed rotor angular location. By 'fixing' the position of the forward blades, one can track the disturbance of the forward rotor as the rear rotor moves by. The decay and spreading of the forward blade wakes and the upstream propagation of the rear blade disturbance are shown along with the interaction of the flow disturbances from the two sets of blades. Author

A91-12512*# MCAT Inst., San Jose, CA.
APPLICATION OF CFD TO SONIC BOOM NEAR AND MID FLOW-FIELD PREDICTION
SAMSON H. CHEUNG (MCAT Institute, San Jose, CA), THOMAS A. EDWARDS, and SCOTT L. LAWRENCE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-3999) Copyright

A three-dimensional parabolized Navier-Stokes (PNS) code has been used to calculate the supersonic overpressures from three different geometries at near- and mid-flow fields. Wind-tunnel data is used for code validation. Comparison of the computed results with different grid refinements is shown in this paper. It is observed that a large number of grid points is needed to resolve the tail shock/expansion fan interaction. Therefore, an adaptive grid approach is employed to calculate the flow field. The agreement between the numerical results and the wind-tunnel data confirms that computational fluid dynamics can be applied to the problem of sonic boom prediction. Author

A91-12513*# Grumman Aerospace Corp., Bethpage, NY.
AN EULER CODE PREDICTION OF NEAR FIELD TO MIDFIELD SONIC BOOM PRESSURE SIGNATURES
M. J. SICLARI (Grumman Corporate Research Center, Bethpage, NY) and C. M. DARDEN (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 15 p. refs
(AIAA PAPER 90-4000) Copyright

A new approach is presented for computing sonic boom pressure signatures in the near field to midfield that utilizes a fully three-dimensional Euler finite volume code capable of analyzing complex geometries. Both linear and nonlinear sonic boom methodologies exist but for the most part rely primarily on equivalent area distributions for the prediction of far field pressure signatures. This is due to the absence of a flexible nonlinear methodology that can predict near field pressure signatures generated by three-dimensional aircraft geometries. It is the intention of the present study to present a nonlinear Euler method than can fill this gap and supply the needed near field signature data for many of the existing sonic boom codes. Author

A91-12521*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EFFECT OF ACOUSTIC EXCITATION ON STALLED FLOWS OVER AN AIRFOIL
K. B. M. Q. ZAMAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(AIAA PAPER 90-4009) Copyright

The effect of acoustic excitation on poststalled flows over an airfoil, i.e., flows that are fully separated from near the leading edge, is investigated. The excitation results in a tendency toward reattachment, which is accompanied by an increased lift and reduced drag, although the flow may still remain fully separated. It is found that with increasing excitation amplitude, the effect becomes more pronounced but shifts to a Strouhal number which is much lower than that expected from linear, inviscid instability of the separated shear layer. Author

A91-12530#
SUPPRESSION OF FLOW-INDUCED PRESSURE OSCILLATIONS IN CAVITIES
R. L. SARNO and M. E. FRANKE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-4018)

Experimental methods for suppressing flow-induced pressure oscillations in a shallow open cavity resulting from tangential flows over the cavity are described. The effects of manipulating the shear layer over the cavity leading edge are examined. Static and pulsating fences and steady and pulsating flow injection at the leading edge are studied for their effect on cavity sound pressure levels. Both subsonic and supersonic flow conditions are considered. Of the methods tested static fences at the leading edge were found to provide the most suppression. Suppression was dependent on the frequency mode and the flow Mach number. Author

A91-12535#
NUMERICAL SIMULATION OF SUPERSONIC MIXING LAYER USING HIGH RESOLUTION SCHEME
PONG-JEU LU and KUEN-CHUAN WU (National Cheng Kung University, Tainan, Republic of China) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 15 p. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-79-0401-E006-44)
(AIAA PAPER 90-4025) Copyright

Two-dimensional direct numerical simulations for a confined inviscid spatially-growing supersonic mixing layer have been conducted. The nonlinear shear-layer development and the corresponding flow structures are examined on the basis of numerical flow visualizations and Favre-averaged turbulence results. It is determined that the numerically visualized downstream compression/expansion wave system explains the 'strange waves' observed in experiments and is responsible for the rapid growth of the mixing layer in that region. It is found that shock induced mixing improvement is local and may be followed by saturation in turbulent energy which impedes the further growth of the shear layer. This and subsequent observations suggest that compressibility effects may behave in a considerably different manner as the underlying instability mechanism changes from the subsonic Kelvin-Helmholtz type to the present supersonic instability wall type. L.K.S.

A91-12559
THEORY OF SLIGHTLY BLUNTED AXISYMMETRIC POWER-LAW BODIES AT SMALL ANGLE OF ATTACK IN HYPERSONIC FLOW [THEORIE DES FAIBLES INCIDENCES EN HYPERSONIQUE POUR LES CORPS AXISYMETRIQUES EN LOI DE PUISSANCE ET A EMOUSSEMENT FAIBLE]
ALAIN MERLEN (ONERA; Lille I, Universite, France) Academie des Sciences, Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 310, no. 5, March 1, 1990, p. 465-470. In French. refs
Copyright

As a generalization of the nonstationary analogy, the noninstantaneous explosion of an infinite rectilinear wire in a uniform flow is related to the hypersonic flow around a slightly blunted axisymmetric power-law body at small angle of attack. Aerodynamic coefficients are analytically calculated and compared to the results of the Newtonian theory. Author

A91-12575
A UNIFIED UNSTEADY LIFTING-LINE THEORY [UNE THEORIE UNIFIEE DE LA LIGNE PORTANTE]
JEAN-LUC GUERMOND and ANTOINE SELLIER (Bassin d'Essais des Carenes, Paris, France) Academie des Sciences, Comptes Rendus, Serie II - Mecanique, Physique, Chimie, Sciences de la Terre et de l'Univers (ISSN 0764-4450), vol. 311, no. 1, July 5, 1990, p. 21-26. In French. refs
Copyright

A unified unsteady lifting-line theory is presented. The solution of the integral equation of the problem yields an asymptotic expansion which is uniformly valid with respect to the frequency of perturbations. The wing may be curved or inclined with respect to the flow. Author

A91-12690*# Analytical Services and Materials, Inc., Hampton, VA.
APPLIED ASPECTS OF LAMINAR-FLOW TECHNOLOGY
A. L. BRASLOW (Analytical Services and Materials, Inc., Hampton, VA), D. V. MADDALON, D. W. BARTLETT, R. D. WAGNER (NASA, Langley Research Center, Hampton, VA), and F. S. COLLIER, JR. (High Technology Corp., Hampton, VA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 47-78. refs
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An account is given of the development status and performance levels achieved with natural laminar flow (NLF), extended wing chord laminar flow control (LFC), and hybrid laminar flow control (HLFC) concepts combining NLF and partial-chord LFC in the leading-edge region. Attention is given to NLF wing structure construction methods capable of achieving the requisite surface-irregularity tolerances, LFC through wing surface suction slots or perforated skins, and the deleterious effects of insects, ice crystals, and noise disturbance inputs on the ability of NLF, LFC, and HLFC wings to maintain effective laminar flow operation. O.C.

A91-12692#
APPLICATION OF CFD TO REDUCTION OF SKIN-FRICTION DRAG
TUNCER CEBECI (Douglas Aircraft Co., Long Beach, CA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 115-178. refs
Copyright

The present development status evaluation of practical techniques for the reduction of skin-friction drag and their associated, CFD-employing design processes gives attention to such aircraft structure components as wings and fuselages, but is broadly relevant to all vehicle classes. The optimization of a geometrical configuration to minimize drag involves the calculation of drag for a range of geometries and surface conditions encompassing cooling, suction, and injection; this is best conducted with a computer-based method of known reliability, and may involve the computation of flows for many configurational alternatives and their boundary conditions. O.C.

A91-12695*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OUTER-LAYER MANIPULATORS FOR TURBULENT DRAG REDUCTION
J. B. ANDERS, JR. (NASA, Langley Research Center, Hampton, VA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 263-284. refs
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The last ten years have yielded intriguing research results on aerodynamic boundary outer-layer manipulators as local skin friction reduction devices at low Reynolds numbers; net drag reduction device systems for entire aerodynamic configurations are nevertheless noted to remain elusive. Evidence has emerged for dramatic alterations of the structure of a turbulent boundary layer which persist for long distances downstream and reduce wall shear as a results of any one of several theoretically possible mechanisms. Reduced effectiveness at high Reynolds numbers may, however, limit the applicability of outer-layer manipulators to practical aircraft drag reduction. O.C.

A91-12696*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONVEX CURVATURE CONCEPT OF VISCOUS DRAG REDUCTION

PROMODE R. BANDYOPADHYAY (NASA, Langley Research Center, Hampton, VA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 285-324. refs
(Contract NAS1-18235; NAS1-18599)
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Experiments have indicated that for certain convex aerodynamic surface curvature ratios, wall-shear stresses remain low over considerable streamwide distances even after curvature is removed. The research whose progress is presently evaluated was first suggested by Bushnell (1983), who proposed that the convex-surface curvature be used in axisymmetric bodies to ascertain whether the viscous component of total drag is reduced. Attention is given to the evolution of the concept's implementation in an axisymmetric nose-body combination for passive viscous drag reduction. O.C.

A91-12698*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VISCOUS DRAG REDUCTION VIA SURFACE MASS INJECTION
JERRY N. HEFNER and DENNIS M. BUSHNELL (NASA, Langley Research Center, Hampton, VA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 457-476. refs
Copyright

Slot injection systems on the surfaces of aerodynamic bodies have been noted to consistently furnish substantial local skin friction reductions which are predictable on the basis of current numerical methods. Only crude systems studies, however, have been thus far completed. The most common configuration for slot ingestion in the literature involves tangential injection of air along a two-dimensional surface on which air constitutes the mainstream flow; attention is presently given to slot injection in low-speed and high-speed flows, as well as a discussion of aircraft applications and an evaluation of prospective possibilities for practical drag-reduction systems. O.C.

A91-12751
APPLIED COMPUTATIONAL AERODYNAMICS
P. A. HENNE, ED. (Douglas Aircraft Co., Long Beach, CA) Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 125), 1990, 951 p. For individual items see A91-12752 to A91-12775.
Copyright

The present volume discusses the original development of the panel method, the mapping solutions and singularity distributions of linear potential schemes, the capabilities of full-potential, Euler, and Navier-Stokes schemes, the use of the grid-generation methodology in applied aerodynamics, subsonic airfoil design, inverse airfoil design for transonic applications, the divergent trailing-edge airfoil innovation in CFD, Euler and potential computational results for selected aerodynamic configurations, and the application of CFD to wing high-lift systems. Also discussed are high-lift wing modifications for an advanced-capability EA-6B aircraft, Navier-Stokes methods for internal and integrated propulsion system flow predictions, the use of zonal techniques for analysis of rotor-stator interaction, CFD applications to complex configurations, CFD applications in component aerodynamic design of the V-22, Navier-Stokes computations of a complete F-16, CFD at supersonic/hypersonic speeds, and future CFD developments. O.C.

A91-12753#
LINEAR POTENTIAL SCHEMES
J. L. HESS (Douglas Aircraft Co., Long Beach, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 21-36. refs
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The present account of linear potential schemes notes their mapping solutions to be based on the intimate connection between any problem governed by the two-dimensional Laplace equation and the theory of functions of a complex variable. The linear nature of the potential-flow problem invites use of the principle of superposition to construct solutions to problems through the summing of simpler solutions; the bodies thus discretized are said to be composed of 'panels'. The boundary conditions for a panel method consist of (1) the zero normal-velocity boundary condition applied to one control point for each panel on the body surface; (2) the Kutta condition applied to the trailing edges of lifting portions of the configuration; and (3) the zero normal velocity and zero pressure jump conditions applied along the trailing vortex wake. O.C.

A91-12755#
GRID-GENERATION METHODOLOGY IN APPLIED AERODYNAMICS
JOHN P. STEINBRENNER (General Dynamics Corp., Fort Worth, TX) and DALE A. ANDERSON (Texas, University, Arlington) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 91-130. refs
Copyright

The present account of CFD grid-generation methodology proceeds by considering such elements of flowfield domain discretization as structured and unstructured grid concepts and single- and multiple-block concepts. Attention is then given to various currently employed methods of grid generation with a view to their aerodynamic applications. Discussions are restricted to steady-state flows, and adaptive gridding methods being developed for time-accurate problems are treated only from a static standpoint in which an approximately converged flow solution is used to modify the original grid to enhance overall accuracy. O.C.

A91-12756#
SUBSONIC AIRFOIL DESIGN
ROBERT H. LIEBECK (Douglas Aircraft Co., Long Beach, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 133-165. refs
Copyright

The James (1971) subsonic airfoil design methodology, whose applications-development history is presented, furnishes exact solutions to the direct and inverse airfoil design problems. In the inverse case, the desired airfoil velocity distribution, described as a function of arc length along the airfoil surface itself, is employed. Leading and trailing edge singularities are treated exactly by the James method, with the input velocity distribution defining the trailing edge angle. Applications illustrating the use of the method encompass low Reynolds number airfoils, wind turbine blade sections, aerobatic aircraft wings, sailboat rudders, race car spoilers, and pterosaur model wings. O.C.

A91-12757#
ELEMENTS OF AIRFOIL DESIGN METHODOLOGY
MARK DRELA (MIT, Cambridge, MA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 167-189. Research supported by MIT. refs
Copyright

An account is given of the state-of-the-art in two-dimensional CFD airfoil design methodology. The two very different airfoil design cases presented are illustrative of the numerous and complex decisions that must be made in the course of airfoil profile definition, and of the essential role played by a fast viscous analysis method. Attention is given to the currently most popular viscous analysis methods; it is noted that Navier-Stokes methods are at present unsuitable for routine aircraft design work, due to excessive computational requirements. The importance of furnishing designers with the greatest possible airfoil-modification flexibility and graphics-based interactive input/output systems is emphasized. O.C.

A91-12758#
INVERSE AIRFOIL DESIGN - A CLASSICAL APPROACH UPDATED FOR TRANSONIC APPLICATIONS
G. VOLPE (Grumman Corporate Research Center, Bethpage, NY) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 191-220. refs

In the inverse airfoil design methodology presented, three free parameters are numerically adjusted in order to drive the freestream speed and trailing-edge gap dimensions to prescribed values. These trailing-edge parameters are introduced in such a fashion that only one of the design constraints is primarily affected, allowing the formulation of an iterative scheme of iterative type in which the three parameters can be ascertained on the basis of three uncoupled one-dimensional relaxation methods. The overall effect of these method components is a robustness which yields speed distributions closely approximating an arbitrarily prescribed ideal. O.C.

A91-12759#
INNOVATION WITH COMPUTATIONAL AERODYNAMICS - THE DIVERGENT TRAILING-EDGE AIRFOIL
P. A. HENNE (Douglas Aircraft Co., Long Beach, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 221-261. refs

The divergent trailing-edge (DTE) airfoil concept emerged from a CFD study conducted in 1981, which predicted enhanced effectiveness from small variations in airfoil contour near the trailing edge. In addition to witnessing airfoil design and testing, the years since these initial discoveries have seen wing-development efforts concerned with three-dimensional, swept-wing transport aircraft applications of DTE predicated on high performance supercritical wing configurations. Since the DTE airfoil will generate a significant increase in circulation over a conventional airfoil, spanwise-loading changes will result from partial-span application of the DTE concept. The availability of powerful CFD resources has been invaluable to DTE development. O.C.

A91-12760*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EULER AND POTENTIAL COMPUTATIONAL RESULTS FOR SELECTED AERODYNAMIC CONFIGURATIONS
R. M. HICKS, S. E. CLIFF, J. E. MELTON, R. G. LANGHI, A. M. GOODSELL (NASA, Ames Research Center, Moffett Field, CA) et al. IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 263-385. refs

A selection of CFD successes and failures is evaluated, on the basis of experimental data/CFD result correlations involving full-potential and Euler computations of the aerodynamics of four commercial transport wings and two low aspect ratio delta wings. An effort is made to ascertain optimum values for grid density and distribution, artificial dissipation, Courant-Friedrichs-Lewy number, enthalphy damping, and a multigrid scheme for each flow condition and configuration analyzed. It is demonstrated that CFD solutions can assist the experimentalist prior to a test by indicating the locations of high pressure gradients and projecting test condition limitations due to balance design limits. O.C.

A91-12761#
COMPUTATIONAL AERODYNAMICS APPLIED TO HIGH-LIFT SYSTEMS
G. W. BRUNE and J. H. MCMASTERS (Boeing Co., Seattle, WA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 389-433. refs

Confluent boundary layers and flow separation are critical differences from cruise-lift airfoil configurations which must be treated by high-lift airfoil designers using CFD. An account is presently given of the character and performance of viscous methods devised for the analysis of multielement slotted airfoils; these methods are classifiable as (1) coupled attached flow; (2) coupled separated flow; (3) Navier-Stokes; and (4) design and optimization. The nature of the flow around three-dimensional high-lift airfoil configurations is further complicated by the geometric complexities of part-span slotted flaps and their supporting tracks, wing and flap sweep, spanwise geometry variations, and engine nacelles. O.C.

A91-12762*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DEVELOPMENT OF HIGH-LIFT WING MODIFICATIONS FOR AN ADVANCED CAPABILITY EA-6B AIRCRAFT
EDGAR G. WAGGONER (NASA, Langley Research Center, Hampton, VA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 435-457. refs

NASA-Langley has been in a development program aimed at improvements of the EA-6B electronic countermeasures aircraft's maneuvering capabilities; one objective of this effort is the investigation of relatively simple wing design modifications which could yield improved low speed high lift performance with minimum degradation of higher-speed performance. Various two- and three-dimensional low speed and transonic CFD techniques have accordingly been used during the design effort, which involved leading-edge slat and trailing-edge flap contour evaluations by both computation and wind tunnel experiment. Significant low-speed maximum-lift enhancements were obtained without cruise-speed deterioration. O.C.

A91-12763#
NAVIER-STOKES METHODS FOR INTERNAL AND INTEGRATED FLOW PREDICTION
RAYMOND R. COSNER (McDonnell Douglas Corp., Saint Louis, MO) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 461-478. refs

The most important phenomena encountered in internal aerodynamic flows are most effectively addressed by means of CFD methods based on the Reynolds-averaged Navier-Stokes equations. Currently, problems are being treated using single-zone and multizone methods whose boundary conditions are appropriate for internal flow. The split flow paths, bifurcated ducts, inlet bleed, secondary air removal/addition, and other flow-path complexities encountered in internal flows have entailed the modification of existing codes developed for simpler problems. As with all CFD applications, the use of these tools is impeded by the high cost of analysis; in order to justify such high computational costs, the solutions must apply to the exact geometry and furnish high-confidence answers. O.C.

A91-12764*# Sterling Federal Systems, Inc., Palo Alto, CA.
COMPUTATIONAL ANALYSIS OF ROTOR-STATOR INTERACTION IN TURBOMACHINERY USING ZONAL TECHNIQUES
NATERI K. MADAVAN (Sterling Federal Systems, Inc., Palo Alto, CA) and MAN MOHAN RAI (NASA, Ames Research Center, Moffett Field, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 481-529. Research supported by the U.S. Navy. refs

The development of CFD zonal techniques which allow more intensive computational treatment in some regions than in others, in conjunction with robust, high-accuracy algorithms for the numerical solution of the Navier-Stokes equations, is presently shown to have facilitated the investigation of rotor-stator interactions in turbomachinery. Attention is given to integration schemes with two and three spatial dimensions, the conservative 'patched' and the nonconservative zonal boundary schemes, and such natural boundary conditions as those of the endwall, the

stator inlet, the airfoil surface, and the rotor exit. Illustrative three-dimensional rotor-stator interaction calculations are presented. O.C.

A91-12765#
EULER/NAVIER-STOKES CALCULATIONS OF THE FLOWFIELD OF A HELICOPTER ROTOR IN HOVER AND FORWARD FLIGHT
RAMESH K. AGARWAL and JERRY E. DEESE (McDonnell Douglas Research Laboratories, Saint Louis, MO) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 533-555. refs
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The Euler/Navier-Stokes code designated 'MDROTH' has been developed for calculating the flowfield of a multibladed helicopter rotor in hover and forward flight. The code obtains the flowfield by solving the three-dimensional Euler/Navier-Stokes equations in a rotating coordinate system on body-conforming curvilinear grids around the blades. The equations are solved for the absolute-flow variables by employing Jameson's (1981) finite-volume explicit Runge-Kutta time-stepping scheme. Viscous effects are modeled via the thin-layer approximation to the Reynolds-averaged Navier-Stokes equations, in conjunction with the Baldwin-Lomax algebraic turbulence model. O.C.

A91-12766#
CFD APPLICATIONS TO COMPLEX CONFIGURATIONS - A SURVEY
EDWARD N. TINOCO (Boeing Co., Seattle, WA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 559-615. refs
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An account is given of state-of-the-art, primarily inviscid CFD applications to complex aircraft configurations. The ability of panel methods to model complex configurations without recourse to flowfield grid generation, as well as their comparative computational economy, has led to their adoption in many applications. Such linear panel methods as A502/PAN AIR, HISS, and QUADPAN, can employ the same paneling model for both subsonic and supersonic analysis. As a configuration is further refined, CFD can be used to ascertain control effectiveness, viscous effects, wake and flowfield characteristics, weapons store behavior, and engine/airframe integration effects. Attention is given to 747-300 flight test comparisons with CFD data, 737-300 wind tunnel comparisons with CFD data, and CFD studies of propfan installations. O.C.

A91-12767#
COMPUTATIONAL AERODYNAMICS APPLIED TO GENERAL AVIATION/BUSINESS AIRCRAFT
NEAL J. PFEIFFER (Beech Aircraft Corp., Wichita, KS) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 617-635. refs
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After an account of the difficulties and requirements for the integration of CAD data on aircraft designs with CFD analyses of their aerodynamic characteristics, attention is given to a NASA-Langley method which appears uniquely suited to the CFD characterization of business turboprop configurations with aft fuselage nacelles located close to the wings, such as the canard-configuration Beech Starship. This method allows the direct tailoring of the wing for close proximity of the nacelle through a definition of target pressure distributions. VSAERO has been used to analyze the entire configuration and generate aerodynamic loads. Attention is given to the effects of canard flow on wing and nacelle flow. O.C.

A91-12768#
APPLICATION OF COMPUTATIONAL FLUID DYNAMIC METHODS TO THE COMPONENT AERODYNAMIC DESIGN OF THE V-22 OSPREY TILT ROTOR VEHICLE
J. C. NARRAMORE (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 637-678. refs
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An account is given of the CFD methods used to develop the aerodynamic contours of the V-22 tilt-rotor vehicle, where distinct problems were posed by rotor blade design, wing design, fuselage fairing contours, nacelle inlet optimization, and airload distributions over the entire configuration. The CFD codes used encompassed GRUMFOIL, ARC2D, VSAERO, and NASTRAN. Both wing and rotor airfoil profiles were treated with the Aerodynamic Design and Analysis Methodology. The CFD results obtained not only direct the tailoring of aerodynamic contours in the direction of performance specifications, but furnish aerodynamic loads information to structural systems designers. O.C.

A91-12769#
AERODYNAMIC ANALYSIS USING EULER EQUATIONS - CAPABILITIES AND LIMITATIONS
PRADEEP RAJ (Lockheed Aeronautical Systems Co., Burbank, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 679-700. Research supported by the Lockheed Aeronautical Systems Co. refs
Copyright

An evaluation is presented of the capabilities of a representative Euler CFD code, the Three-dimensional Euler/Navier-Stokes Aerodynamic Method, 'TEAM', in light of three criteria: configuration geometry, flow conditions, and solution accuracy. For many cases, sensitivity to grid density, numerical dissipation, and boundary condition treatment are also evaluated. The six illustrative test cases considered are the NLR 7301 airfoil, a transonic maneuvering-optimized fighter wing, a 74-deg delta wing, a cone-derived Mach 6 waverider configuration, a canard-wing-body configuration, and an Advanced Nozzle Concept fighter configuration. The TEAM code is found to accommodate patched multizone structured grids of arbitrary topologies, thereby facilitating complex configuration analyses. O.C.

A91-12770*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TOWARD THE ROUTINE AERODYNAMIC ANALYSIS OF COMPLEX CONFIGURATIONS
MICHAEL D. MADSON and LARRY L. ERICKSON (NASA, Ames Research Center, Moffett Field, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 701-751. refs
(Contract NAS2-12513)
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An evaluation is made of the ability of the TranAir CFD code to routinely compute the aerodynamic characteristics of complex subsonic and supersonic aircraft configurations. TranAir solves the full-potential equation for transonic flow about completely arbitrary geometries, using the surface-paneling PanAir technique in geometry definition. The uniform global grid may be locally refined in regions where flow properties are rapidly changing, such as regions where shocks arise, and around wing leading edges. Unlike panel method codes, TranAir solutions are not undermined by small-perturbation assumptions. Illustrative results are presented for such configurations as the F-16A with wingtip-mounted missiles and underwing fuel tanks, a generic fighter configuration, and a model of NASA-Ames' 12-ft Pressure Wind Tunnel. O.C.

A91-12771#
COMPUTATIONAL AERODYNAMIC SIMULATION EXPERIENCE
E. BONNER, C. J. WOAN, and G. J. SOVA (Rockwell International Corp., Los Angeles, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 753-776. refs
Copyright

Advancements in CFD algorithms and computer hardware are leading to substantial progress in numerical aircraft simulation and design methodologies. Recent aeroelastic and separated flow simulation results are indicative of emerging capabilities for

additional design problems, although grid generation capability is noted to remain an advancement-pacing factor in such simulation efforts generally, and an altogether critical factor in complex geometry/viscous flow resolution. Early inputs from numerical analyses into design programs entail a compatibility of overall grid size limits with conceptual development activity, in terms of both the time and computational resources available. O.C.

A91-12772*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NAVIER-STOKES COMPUTATIONS ABOUT COMPLEX CONFIGURATIONS INCLUDING A COMPLETE F-16 AIRCRAFT
TERRY L. HOLST, JOLEN FLORES, NEAL M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA), and UNVER KAYNAK (Sterling Software, Inc., Palo Alto, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 777-815. refs
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Transonic Navier-Stokes (TNS) code solutions gathered from the literature for three-dimensional geometries, including two different wings and a complete F-16A aircraft, are presently discussed. The TNS codes use a zonal grid approach whose number of zones vary from four to 54. The Euler equations are solved in zones away from no-slip surfaces, and the thin-layer TNS equations are solved in all zones immediately adjacent to no-slip surfaces. In the case of 'corner' zones possessing no-slip boundary conditions on two different surfaces, a thin-layer formulation along both directions is employed. Employing these features, a zonal construction with the requisite set of boundary conditions can be devised for almost any application. O.C.

A91-12773#
COMPUTATIONAL FLUID DYNAMICS DESIGN APPLICATIONS AT SUPERSONIC/HYPERSONIC SPEEDS
H. ROBERT WELGE (Douglas Aircraft Co., Long Beach, CA) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 817-838. refs
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Four cases are presented and discussed, in order of increasing complexity, to illustrate the impact of advanced CFD methods on supersonic/hypersonic cruise aircraft design. The first case demonstrates the use of interactive computer graphics to visualize complex flowfields in conjunction with CFD methods; the second case treats sonic boom ground-level pressure signal prediction via CFD, with attention to hypersonic speeds and nonslender configurations which cannot be dealt with under linear assumptions. The third case is the design of a wing for Mach 2.2 cruise which incorporates laminar boundary-layer flow and increased leading-edge suction. Finally, attention is given to the complex internal flows of a Mach 5 engine inlet; these involve strong shocks and viscous interactions with high three-dimensionality. O.C.

A91-12882#
GUST RESPONSE FOR FLAT-PLATE AIRFOILS AND THE KUTTA CONDITION
R. K. AMIET (AMI, Wooster, OH) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1718-1727. refs
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The case of a flat plate airfoil encountering a gust in incompressible flow is analyzed, with the generalization that the shed vorticity in the wake as well as the incident gust can convert at arbitrary velocity relative to the freestream. Bound vorticity and loading are calculated. At high frequency the bound vorticity is shown to be equivalent to an image of the incident gust, and drifts with the gust, except near the leading edge, and if the gust velocity is unequal to the wake velocity, near the trailing edge. When the wake moves relative to the freestream, there is a loading on the wake which forces nonzero loading at the trailing edge. A recent vortex chopping model is shown to depend explicitly on this fictitious wake loading, raising questions about the resulting noise prediction. A clarification in the application of the Kutta condition is given for the case of high frequency gust disturbances when both the gust and the wake drift with the freestream, showing that for inviscid flow the Kutta condition is satisfied automatically as the gust pases the trailing edge by allowing the flow to continue as if the edge were not present. Author

A91-12886#
FORMULATION OF THREE-DIMENSIONAL HODOGRAPH METHOD AND SEPARABLE SOLUTIONS FOR NONLINEAR TRANSONIC FLOWS
GABRIEL OYIBO (Polytechnic University, Farmingdale, NY) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1745-1750. refs
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The three-dimensional hodograph technique presently formulated transforms the full nonlinear potential transonic flow equation from physical space into an equivalent linear counterpart in the hodograph plane. It is established that a mild constraint on the energy equation allows the separation of an aircraft wing's nonlinear flow equations into a sectional and a spanwise component; the consequent 'three-dimensional' sectional equation is eventually transformed onto the hodograph plane, where it becomes linear. With one further transformation into the characteristic hodograph plane, it becomes possible to obtain the nonlinear flowfield for a particular set of boundary conditions by solving a set of first-order characteristic equations. O.C.

A91-12896#
LOCALIZED LINEARIZATION METHOD FOR WINGS AT HIGH ANGLE OF ATTACK
LING-CHENG ZHAO (Northwestern Polytechnical University, Xian, People's Republic of China) and ZHENG-YIN YE AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1820-1822.
Copyright

A localized linearization method is devised which extends the use of the vortex lattice method (VLM) for the case of wings at high angle of attack and subcritical Mach number. The method preserves the VLM's advantages without involving the flowfield discretization, thereby remaining a surface boundary-element formulation. Illustrative delta and rectangular planform wings of small aspect ratio are calculated by means of this method for different Mach numbers. O.C.

A91-12899#
EULER SOLUTIONS FOR DELTA WINGS
ANDREW B. WARDLAW, JR. and STEPHEN F. DAVIS (U.S. Navy, Naval Surface Warfare Center, Silver Spring, MD) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1826-1829. Research supported by the U.S. Navy. refs

Numerical experiments with Euler solutions for delta wings of varying thickness, with different meshes, varying levels of artificial viscosity, and upwind as opposed to centrally differenced schemes, have yielded conflicting solution types for the same given problem. An examination is presently conducted of the conditions under which the separated solutions form. The evolution of the separated solution is traced, and the numerical factors influencing the inviscid solution type are characterized. O.C.

A91-12903*# State Univ. of New York, Buffalo.
PREDICTION OF INVISCID STAGNATION PRESSURE LOSSES IN SUPERSONIC INLET FLOWS
DAVID J. AZEVEDO, CHING SHI LIU, and WILLIAM J. RAE (New York, State University, Buffalo) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1834-1836. refs
(Contract NAGW-966)
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An effort is made to quantify the stagnation pressure losses associated with shock-wave systems that may be present in such high Mach number flows as those of scramjet hypersonic diffusers. If the shock-related contribution turns out to be much larger than that attributable to viscous effects, a designer could introduce methods for the minimization of the shock system's scale; in particular, the size of the normal shock should be reduced. The

angles presently treated may be approached during vehicle maneuvering or other transients. O.C.

A91-12904#
TRANSONIC COMPUTATIONS ON A NATURAL GRID
R. M. BARRON (Windsor, University, Canada) and R. K. NAEEM AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1836-1838. Research supported by NSERC. refs
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The natural grid system generated by Barron and Naeem's (1989) von Mises transformation for the finite-difference solution of transonic full-potential flows yields a finest grid, for the case of a NACA 0012 airfoil at Mach 0.8, which provides about 30 surface grid points. This leads to problems in near-surface calculations in the supersonic region. Attention is presently given to a simple scheme precluding this grid-refinement problem. O.C.

A91-12911
PRACTICAL AERODYNAMICS AND FLIGHT DYNAMICS OF YAK-52 AND YAK-55 AIRCRAFT [PRAKTICHESKAIA AERODINAMIKA I DINAMIKA POLETA SAMOLETOV IAK-52 I IAK-55]
ANATOLII E. KOROVIN and IURII F. NOVIKOV Moscow, Izdatel'stvo DOSAAF SSSR, 1989, 360 p. In Russian.
Copyright

The principal aerodynamic, performance, and handling characteristics of Yak-52 and Yak-55 aircraft are reviewed in a systematic manner, with emphasis on the underlying physical principles. The discussion covers the geometry of the aircraft, aerodynamic characteristics of the wing and the airframe, characterization of the power plant and propeller aerodynamics, and climb and cruising flight characteristics. Attention is also given to aircraft stability, takeoff and landing characteristics, and maneuverability. V.L.

A91-12913
JETS AND LIFTING SURFACES: COMPUTER SIMULATION [STRUI I NESUSHCHIE POVERKHNOSTI: MODELIROVANIE NA EVM]
VLADIMIR I. BABKIN, SERGEI M. BELOTSERKOVSKII, VALERII V. GULIAEV, and ALEKSANDR V. DVORAK Moscow, Izdatel'stvo Nauka, 1989, 208 p. In Russian. refs
Copyright

The interaction of jets with lifting surfaces and obstacles is investigated through systematic computer simulations using the discrete vortex method. The discussion covers the general properties of jet flows and problems with liquid boundaries; the principles of the discrete vortex method; and application of the discrete vortex method to thin jet problems and stationary problems for jets of finite thickness. Attention is also given to the aerodynamic characteristics of wings with allowance for interference with the operating power plant; aerodynmic characteristics of an airfoil in the path of a jet flow; and two- and three-dimensional jets of an ideal liquid. V.L.

N91-10003 National Aerospace Lab., Tokyo (Japan).
CHARACTERISTICS OF PIPING INTERFERENCE ELIMINATION UNIT USED IN THE HIGH-SPEED WIND TUNNEL TEST OF ASUKA SEVEN PERCENT SEMI-BORN PROTOTYPE [ASUKA NANA PASENTO HANSETSU MOKEI NO KOUSOKU FUUDOU SHIKEN NI MOCHIITAHAIKAN KANSHOU JOKYO SOUCHI NO TOKUSEI NI TSUITE]
NOBUYUKI HOSOE, TOSHIO KARASAWA, KEISUKE ASAI, SYOUJI SUENAGA, YO KOIKE, HIROKAZU SUZUKI, MASAYOSHI NAKAMURA, and SUSUMU MITSUBORI Jun. 1988 17 p In JAPANESE
(NAL-TM-588; ISSN-0452-2982; JTN-90-80015) Avail: NTIS HC/MF A03

In the high-speed aerodynamic test using a seven percent semiborne model for the low-noise STOL test aircraft, two TPS (Turbine Powered Simulators) were mounted for use in order to simulate the drive of an actual aircraft. In order to suppress the influence of the piping for supplying compressed air to the TPS measurement of air power by a balance of an external mount type (six percent balance), a unit for eliminating the influence of the piping was manufactured by way of trial. Factors which influence the piping measurement of air power are as follows: effect of air pressure in the piping, influence by the twisting and warping of the piping as a result of a change in the stance of the model, influence by the division of air power between the balance and the piping due rigidity of the piping itself, influence of thermal elongation and contraction of the piping, influence of the flow of compressed air in the piping. To minimize these influences, use was made of a combination of Zimbal bellow, high-pressure rubber hose, and apherical joint was made for eliminating the influence of the piping on an experimental basis which was checked for effect by conducting a wind-tunnel test with and without introduction of air. NASDA

N91-10006 Georgia Inst. of Tech., Atlanta.
APPLICATION OF A STATE-SPACE WAKE MODEL TO ELASTIC BLADE FLAPPING IN HOVER Ph.D. Thesis
AY SU 1989 145 p
Avail: Univ. Microfilms Order No. DA9014871

A finite-state inflow model is developed that models the three-dimensional rotor inflow in hover, axial flight, or forward flight. The basis of the model is an acceleration potential with a skewed cylindrical wake. The scope and objectives of the present research revolve around the development of this theoretical basis into a useful research and design tool for hover and axial flight. First, we establish the harmonic and radial convergence characteristics of the model. One-bladed and four-bladed rotors are used in this analysis. Second, this model is coupled with elastic-blade flap equations in hover and also in axial flight in order to determine its effect on aerodynamic damping. Third, the role of periodic coefficients in the dynamic response is investigated. A multi-blade coordinate transformation technique is used to transform the flap equations from the rotating to the nonrotating system. Similarly, the induced flow can be written in either the rotating or the nonrotating system. The effect of periodic coefficients is dependent upon which set of blade equations is coupled with which set of inflow equations. Fourth, we related the generalized forces in the inflow equations to the generalized forces already being used for structural response by constructing intermediate transformation matrices. Results obtained from these tasks show that the present model converges with 3 shape functions per harmonic and has high computational efficiency as compared to unsteady vortex-filament models. More importantly, results indicate that unsteady inflow is an important physical phenomenon that changes the qualitative nature of rotor dynamics in hover and in axial flight. Dissert. Abstr.

N91-10007*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRANSONIC FLOW ANALYSIS FOR ROTORS. PART 3: THREE-DIMENSIONAL, QUASI-STEADY, EULER CALCULATION
I-CHUNG CHANG Jun. 1990 23 p
(NASA-TP-2375; A-86374-PT-3; NAS 1.60:2375) Avail: NTIS HC/MF A03 CSCL 01A

A new method is presented for calculating the quasi-steady transonic flow over a lifting or non-lifting rotor blade in both hover and forward flight by using Euler equations. The approach is to solve Euler equations in a rotor-fixed frame of reference using a finite volume method. A computer program was developed and was then verified by comparison with wind-tunnel data. In all cases considered, good agreement was found with published experimental data. Author

N91-10008# Los Alamos National Lab., NM.
OPTIMUM HYPERSONIC AIRFOIL WITH POWER LAW SHOCK WAVES
B. A. WAGNER 1990 10 p Presented at the 1st International Hypersonic Waverider Symposium, College Park, MD, Oct. 1990
(Contract W-7405-ENG-36)

(DE90-014903; LA-UR-90-2437; CONF-9010154-1) Avail: NTIS HC/MF A03

The flow field over a class of 2-D lifting surfaces is examined from the viewpoint of inviscid, hypersonic small disturbance theory (HSDT). It is well known that a flow field in which the shock shape S(x) is similar to the body shape F(x) is only possible for F(x) = x sup k and the freestream Mach number M sub infinity = infinity. This self-similar flow has been studied for several decades as it represents one of the few existing exact solutions of the equations of HSDT. Detailed discussions are found for example in papers by Cole, Mirels, Chernyi and Gersten and Nicolai but they are limited to convex body shapes, that is, k less than or = 1. The only study of concave body shapes was attempted by Sullivan where only special cases were considered. The method used here shows that similarity also exists for concave shapes and a complete solution of the flow field for any k greater than 2/3 is given. The effect of varying k on C sub L sup 3/2 C sub D is then determined and an optimum shape is found. Furthermore, a wider class of lifting surfaces is constructed using the streamlines of the basic flow field and analysed with respect to the effect on C sub L sup 3/2 C sub D. DOE

N91-10010*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

TURBULENT FLOW CALCULATIONS USING UNSTRUCTURED AND ADAPTIVE MESHES Final Report

DIMITRI J. MAVRIPLIS Sep. 1990 32 p Submitted for publication

(Contract NAS1-18605)

(NASA-CR-182102; NAS 1.26:182102; ICASE-90-61) Avail: NTIS HC/MF A03 CSCL 01A

A method of efficiently computing turbulent compressible flow over complex two dimensional configurations is presented. The method makes use of fully unstructured meshes throughout the entire flow-field, thus enabling the treatment of arbitrarily complex geometries and the use of adaptive meshing techniques throughout both viscous and inviscid regions of flow-field. Mesh generation is based on a locally mapped Delaunay technique in order to generate unstructured meshes with highly-stretched elements in the viscous regions. The flow equations are discretized using a finite element Navier-Stokes solver, and rapid convergence to steady-state is achieved using an unstructured multigrid algorithm. Turbulence modeling is performed using an inexpensive algebraic model, implemented for use on unstructured and adaptive meshes. Compressible turbulent flow solutions about multiple-element airfoil geometries are computed and compared with experimental data. Author

N91-10011# National Aerospace Lab., Tokyo (Japan). Aerodynamics Div.

NUMERICAL SIMULATION OF HYPERSONIC FLOW AROUND A SPACE PLANE. PART 3: ANALYSIS OF AEROTHERMODYNAMIC HEATING

YUKIMITSU YAMAMOTO, HARUHIKO ARAKAWA, and RYUJI YOSHIDA (Mitsubishi Heavy-Industries Ltd., Tokyo, Japan) Aug. 1989 30 p

(NAL-TR-1027T; ISSN-0389-4010) Avail: NTIS HC/MF A03

The evaluation of hypersonic aerothermodynamic heating along the wing leading edge of the space plane is very important for preliminary aerothermal structural design, because severe local peak heating is caused there by recompression or shock impingement at low angles of attack. In the present numerical simulation, this local peak heating has been analyzed for the three space plane configurations proposed by the National Aerospace Laboratory (NAL). The proposed models have different wing leading edge sweep angles, and effects of the sweep angles on local peak heating were investigated in detail. In addition, two of the proposed configurations have tip fin controllers, and their heating characteristics were also investigated. As the numerical approach, a flux split upwind TVD scheme was adopted by using thin layer Navier-Stokes equations in a finite volume formulation. An implicit approximately factored ADI method has been used as the solution algorithm. Numerical computations were carried out at M(sub infinity) = 7.0 and Reynolds number of 4.4 x 10(exp 6) at angles of attack alpha = 0, 10, and 20 deg. Numerical results are compared with experimental heat transfer measurements by the infrared system developed in the hypersonic wind tunnel (HWT) at NAL. Author

N91-10013*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

WAKE COUPLING TO FULL POTENTIAL ROTOR ANALYSIS CODE

FRANCISCO J. TORRES, I-CHUNG CHANG, and BYUNG K. OH (Boeing Computer Services Co., Philadelphia, PA.) Aug. 1990 23 p

(NASA-TM-102805; A-90117; NAS 1.15:102805) Avail: NTIS HC/MF A03 CSCL 01A

The wake information from a helicopter forward flight code is coupled with two transonic potential rotor codes. The induced velocities for the near-, mid-, and far-wake geometries are extracted from a nonlinear rigid wake of a standard performance and analysis code. These, together with the corresponding inflow angles, computation points, and azimuth angles, are then incorporated into the transonic potential codes. The coupled codes can then provide an improved prediction of rotor blade loading at transonic speeds. Author

N91-10014*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

EULER AND POTENTIAL EXPERIMENT/CFD CORRELATIONS FOR A TRANSPORT AND TWO DELTA-WING CONFIGURATIONS Technical Memorandum

R. M. HICKS, S. E. CLIFF, J. E. MELTON, R. G. LANGHI, A. M. GOODSELL, D. D. ROBERTSON, and S. A. MOYER Aug. 1990 180 p Original contains color illustrations

(NASA-TM-102208; A-89197; NAS 1.15:102208) Avail: NTIS HC/MF A09; 2 functional color pages CSCL 01A

A selection of successes and failures of Computational Fluid Dynamics (CFD) is discussed. Experiment/CFD correlations involving full potential and Euler computations of the aerodynamic characteristics of four commercial transport wings and two low aspect ratio, delta wing configurations are shown. The examples consist of experiment/CFD comparisons for aerodynamic forces, moments, and pressures. Navier-Stokes equations are not considered. Author

N91-10015*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

APPLICATION OF CFD TO SONIC BOOM NEAR AND MID FLOW-FIELD PREDICTION

SAMSON H. CHEUNG (MCAT Inst., San Jose, CA.), THOMAS A. EDWARDS, and SCOTT L. LAWRENCE Aug. 1990 13 p Presented at the 13th AIAA Aeroacoustic Conference, Tallahassee, FL, 22-24 Oct. 1990

(NASA-TM-102867; A-90246; NAS 1.15:102867) Avail: NTIS HC/MF A03 CSCL 01A

A 3-D parabolized Navier-Stokes (PNS) code was used to calculate the supersonic overpressures from three different geometries at near- and mid-flow fields. Wind tunnel data is used for code validation. Comparison of the computed results with different grid refinements is shown. It is observed that a large number of grid points is needed to resolve the tail shock/expansion fan interaction. Therefore, an adaptive grid approach is employed to calculate the flow field. The agreement between the numerical results and the wind tunnel data confirms that computational fluid dynamics can be applied to the problem of sonic boom prediction. Author

N91-10016# Institut Franco-Allemand de Recherches, Saint-Louis (France).

MODELING BLADE/VORTEX INTERACTIONS [MODELISATION D'INTERACTIONS PALE/TOURBILLON]

P. GNEMMI, JACQUES HAERTIG, and CH. JOHE 24 May 1989 43 p In FRENCH Original contains color illustrations

(ISL-R-107/89; ETN-90-97569) Avail: NTIS HC/MF A03

The development of an electron emitter based on a shallow pn-junction made of gallium arsenide is reported. Desirable properties of an electron gun are outlined and the attractive aspects and specific possibilities of the Avalanche Electron Emitting Diode (AEED) are discussed. Fabrication, including the self-made gold-germanium sputter and gold evaporation equipment, is explained. Ultrahigh vacuum measurement and cleaning setup and properties of the low energy argon ion sputter source and method of measurement are presented. Experimental results and theoretical calculations are given. The Ga AEED device is concluded to be of not good enough quality for fair comparison to the silicon AEED. ESA

N91-10018# Institut Franco-Allemand de Recherches, Saint-Louis (France).

ROTOR LOADS COMPUTATION USING SINGULARITY METHODS AND APPLICATION TO THE NOISE PREDICTION

MARTIN SCHAFFAR and JACQUES HAERTIG 1990 13 p Presented at 3rd International Congress of Fluid Mechanics, Cairo, Egypt, 2-4 Jan. 1990

(ISL-PU-301/90; ETN-90-97577) Avail: NTIS HC/MF A03

In the two dimensional space, two singularity methods are described and applied to the profile/vortex interaction. The results show a good agreement with experiments in a water tunnel. In the three dimensional space, the vortex lattice method, with a local conformal mapping, is described and applied in order to predict the aerodynamic loads on a thick two bladed rotor. The pressure coefficients obtained for the thick rotor are fed into an acoustic code which is based on the Ffowcs-Williams-Hawkings equation. The results obtained with this method show the importance of the rotor and flight parameters. They are compared with results found for a two bladed rotor in hovering and advancing flight. The comparison shows a good agreement and shows that the cut off length used to smooth the singularity of the Biot and Savart law must be chosen carefully. ESA

N91-10019*# Iowa State Univ. of Science and Technology, Ames. Engineering Research Inst.

NUMERICAL COMPUTATION OF VISCOUS FLOW ABOUT UNCONVENTIONAL AIRFOIL SHAPES Final Report

S. AHMED and J. C. TANNEHILL Oct. 1990 82 p

(Contract NAG1-645; ERI PROJ. 1874)

(NASA-CR-187343; NAS 1.26:187343; ISU-ERI-AMES-91-110; CFD-24) Avail: NTIS HC/MF A05 CSCL 01A

A new two-dimensional computer code was developed to analyze the viscous flow around unconventional airfoils at various Mach numbers and angles of attack. The Navier-Stokes equations are solved using an implicit, upwind, finite-volume scheme. Both laminar and turbulent flows can be computed. A new nonequilibrium turbulence closure model was developed for computing turbulent flows. This two-layer eddy viscosity model was motivated by the success of the Johnson-King model in separated flow regions. The influence of history effects are described by an ordinary differential equation developed from the turbulent kinetic energy equation. The performance of the present code was evaluated by solving the flow around three airfoils using the Reynolds time-averaged Navier-Stokes equations. Excellent results were obtained for both attached and separated flows about the NACA 0012 airfoil, the RAE 2822 airfoil, and the Integrated Technology A 153W airfoil. Based on the comparison of the numerical solutions with the available experimental data, it is concluded that the present code in conjunction with the new nonequilibrium turbulence model gives excellent results. Author

N91-10020*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

AEROELASTIC ANALYSIS OF WINGS USING THE EULER EQUATIONS WITH A DEFORMING MESH

BRIAN A. ROBINSON, JOHN T. BATINA, and HENRY T. Y. YANG (Purdue Univ., West Lafayette, IN.) Nov. 1990 11 p Presented at the AIAA/ASME/ASCE/AHS/ASC 31st Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990 Previously announced in IAA as A90-29376

(NASA-TM-102733; NAS 1.15:102733; AIAA-90-1032) Avail: NTIS HC/MF A03 CSCL 01A

Modifications to the CFL3D three dimensional unsteady Euler/Navier-Stokes code for the aeroelastic analysis of wings are described. The modifications involve including a deforming mesh capability which can move the mesh to continuously conform to the instantaneous shape of the aeroelastically deforming wing, and including the structural equations of motion for their simultaneous time-integration with the governing flow equations. Calculations were performed using the Euler equations to verify the modifications to the code and as a first step toward aeroelastic analysis using the Navier-Stokes equations. Results are presented for the NACA 0012 airfoil and a 45 deg sweptback wing to demonstrate applications of CFL3D for generalized force computations and aeroelastic analysis. Comparisons are made with published Euler results for the NACA 0012 airfoil and with experimental flutter data for the 45 deg sweptback wing to assess the accuracy of the present capability. These comparisons show good agreement and, thus, the CFL3D code may be used with confidence for aeroelastic analysis of wings. Author

N91-10022*# Institute for Computer Applications in Science and Engineering, Hampton, VA.

VORTEX INSTABILITIES IN 3D BOUNDARY LAYERS: THE RELATIONSHIP BETWEEN GOERTLER AND CROSSFLOW VORTICES Final Report

ANDREW BASSOM and PHILIP HALL (Exeter Univ., England) Oct. 1990 76 p Submitted for publication Sponsored in part by Science Research Council and AF

(Contract NAS1-18605)

(NASA-CR-187456; NAS 1.26:187456; ICASE-90-72) Avail: NTIS HC/MF A05 CSCL 01A

The inviscid and viscous stability problems are addressed for a boundary layer which can support both Goertler and crossflow vortices. The change in structure of Goertler vortices is found when the parameter representing the degree of three-dimensionality of the basic boundary layer flow under consideration is increased. It is shown that crossflow vortices emerge naturally as this parameter is increased and ultimately become the only possible vortex instability of the flow. It is shown conclusively that at sufficiently large values of the crossflow there are no unstable Goertler vortices present in a boundary layer which, in the zero crossflow case, is centrifugally unstable. The results suggest that in many practical applications Goertler vortices cannot be a cause of transition because they are destroyed by the 3-D nature of the basic state. In swept wing flows the Goertler mechanism is probably not present for typical angles of sweep of about 20 degrees. Some discussion of the receptivity problem for vortex instabilities in weakly 3-D boundary layers is given; it is shown that inviscid modes have a coupling coefficient marginally smaller than those of the fastest growing viscous modes discussed recently by Denier, Hall, and Seddougui (1990). However the fact that the growth rates of the inviscid modes are the largest in most situations means that they are probably the most likely source of transition. Author

N91-10023# Helsinki Univ. Technology, Otaniemi (Finland). Aerodynamics Lab.

THREE-DIMENSIONAL VISCOUS/INVISCID COUPLING IN SUBSONIC FLOW

ZIQUIANG ZHU, SEPPO LAINE, and ESA SALMINEN 1990 27 p

(REPT-B-24; ISBN-951-22-0248-4; ISSN-0358-2620) Avail: NTIS HC/MF A03

Coupling MBB low-order panel code for three-dimensional compressible subsonic potential flow and Stock's boundary layer method for three-dimensional compressible laminar or turbulent flow is proposed. The resulting computer program is valid only for simple wings. The panel model may also contain body-like components, however. The friction drag of the wing is obtained as a result of the computations. The effect of the displacement thickness on the potential solution is simulated iteratively using a

surface transpiration model. A comparison with experimental results shows that the method predicts the trend of the boundary layer effect correctly, although underestimates its magnitude. Author

N91-10024# Helsinki Univ. Technology, Otaniemi (Finland). Aerodynamics Lab.
CALCULATION OF THREE-DIMENSIONAL VISCOUS/INVISCID INTERACTION IN SUBSONIC FLOW
ZIQIANG ZHU, SEPPO LAINE, and ESA SALMINEN 1990 36 p
(REPT-B-25; ISBN-951-22-0329-4; ISSN-0358-2620) Avail: NTIS HC/MF A03

The development of a method to obtain the subsonic viscous flow solution for three-dimensional geometries, using the viscous/inviscid interaction technique, is described. A 3-D panel method (MBB) for calculating three-dimensional inviscid flow is coupled iteratively with a two-dimensional, inverse integral boundary layer method, in which small separation bubbles can be handled. Cross flow is ignored in the boundary layer calculations, which are carried out along chordwise strips of the wing. The surface transpiration approach is used in the coupling. Numerical results indicate that good agreement with experimental data can be obtained up to an angle of attack near maximum lift. Author

N91-10025# Helsinki Univ. Technology, Otaniemi (Finland). Aerodynamics Lab.
EVALUATION OF THE ZONA51D PROGRAM
KARI RENKO 1990 43 p
(REPT-B-28; ISBN-951-22-0398-7; ISSN-0358-2620) Avail: NTIS HC/MF A03

ZONA51D is a computer program which determines the unsteady aerodynamic forces acting on a lifting surface system in supersonic flow. The program is based on the harmonic gradient formulation. The ZONA51D code is installed into the IBM 3090-180E VF computer at the Helsinki University of Technology. Modifications are made to the code to ease its operation and the post-processing of the results. The proper operation of the code and the accuracy of the results is verified by running several test cases and comparing the results to analytical solutions, experimental results, and other representative computations.
Author

N91-10026# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Abt. fuer Numerische Stroemungsmechanik.
A CONTRIBUTION TO THE NUMERICAL SOLUTION OF TRANSONIC FLOW AROUND A DELTA WING BY SOLVING NAVIER-STOKES EQUATIONS Ph.D. Thesis - Karlsruhe Univ.
ACHIM HILGENSTOCK Dec. 1989 101 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1225) Original contains color illustrations
(DLR-FB-90-13; ISSN-0171-1342; ETN-90-97628; AD-B146522L) Avail: NTIS HC/MF A06; DLR, VB-OL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic

The turbulent flow around a delta wing at incidence is simulated numerically using a finite volume Navier-Stokes method. The methods for selecting the optimal grid and the grid generation are outlined. The numerical simulation makes use of a simple algebraic turbulence model. Using a sharp leading edge delta wing, the influence of grid refinement is investigated. The realistic wing body configuration with round leading edge is used to discuss the influence of the position of the transition line. Experimental and numerical data are compared to validate the numerical method. The topological structure of the flow is interpreted. An explanation is given for the low particle density area close to the primary vortex as it is visualized by laser light sheet technique. The distribution of Mach number, velocity, temperature, pressure and total pressure is discussed in connection with the streamlines for the primary vortex. ESA

N91-10027# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt; Cologne (Germany, F.R.). Hauptabt. Windkanaele.
WIND TUNNEL INVESTIGATIONS OF THE APPEARANCE OF SHOCKS IN THE WINDWARD REGION OF BODIES WITH CIRCULAR CROSS SECTION AT ANGLE OF ATTACK
HELMUT ESCH 15 Mar. 1990 63 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1226)
(DLR-FB-90-15; ISSN-0171-1342; ETN-90-97629; AD-B147243L) Avail: NTIS HC/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic

Conditions causing the primary embedded shock to deviate into the windward region of a circular cylinder at angle of attack were investigated by use of Schlieren photos, oil flow pictures, and surface pressure distribution measurements. The critical range of crossflow Mach number greater than or equal to 0.3 and less than or equal to 0.6 was covered at free stream Mach numbers between Ma = 1.25 and 2.5. Reynolds numbers based on body diameter varied between 3 x 10(exp 5) and 1.3 x 10(exp 6).
ESA

N91-10839*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA COMPUTATIONAL FLUID DYNAMICS CONFERENCE. VOLUME 1: SESSIONS 1-6
Sep. 1989 475 p Conference held at Moffett Field, CA, 7-9 Mar. 1989 Original contains color illustrations
(NASA-CP-10038-VOL-1; A-89160-VOL-1; NAS 1.55:10038-VOL-1) Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Presentations given at the NASA Computational Fluid Dynamics (CFD) Conference held at the NASA Ames Research Center, Moffett Field, California, March 7-9, 1989 are given. Topics covered include research facility overviews of CFD research and applications, validation programs, direct simulation of compressible turbulence, turbulence modeling, advances in Runge-Kutta schemes for solving 3-D Navier-Stokes equations, grid generation and invicid flow computation around aircraft geometries, numerical simulation of rotorcraft, and viscous drag prediction for rotor blades.

N91-10840*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPUTATIONAL FLUID DYNAMICS PROGRAM AT NASA AMES RESEARCH CENTER
TERRY L. HOLST *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 3-34 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The Computational Fluid Dynamics (CFD) Program at NASA Ames Research Center is reviewed and discussed. The technical elements of the CFD Program are listed and briefly discussed. These elements include algorithm research, research and pilot code development, scientific visualization, advanced surface representation, volume grid generation, and numerical optimization. Next, the discipline of CFD is briefly discussed and related to other areas of research at NASA Ames including experimental fluid dynamics, computer science research, computational chemistry, and numerical aerodynamic simulation. These areas combine with CFD to form a larger area of research, which might collectively be called computational technology. The ultimate goal of computational technology research at NASA Ames is to increase the physical understanding of the world in which we live, solve problems of national importance, and increase the technical capabilities of the aerospace community. Next, the major programs at NASA Ames that either use CFD technology or perform research in CFD are listed and discussed. Briefly, this list includes turbulent/transition physics and modeling, high-speed real gas flows, interdisciplinary research, turbomachinery demonstration computations, complete aircraft aerodynamics, rotorcraft applications, powered lift flows, high alpha flows, multiple body aerodynamics, and incompressible flow applications. Some of the individual problems actively being worked in each of these areas is listed to help define the breadth or extent of CFD involvement

in each of these major programs. State-of-the-art examples of various CFD applications are presented to highlight most of these areas. The main emphasis of this portion of the presentation is on examples which will not otherwise be treated at this conference by the individual presentations. Finally, a list of principal current limitations and expected future directions is given. Author

N91-10841*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL FLUID DYNAMICS RESEARCH AND APPLICATIONS AT NASA LANGLEY RESEARCH CENTER
JERRY C. SOUTH, JR. *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 35-47 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Information on computational fluid dynamics (CFD) research and applications carried out at the NASA Langley Research Center is given in viewgraph form. The Langley CFD strategy, the five-year plan in CFD and flow physics, 3-block grid topology, the effect of a patching algorithm, F-18 surface flow, entropy and vorticity effects that improve accuracy of unsteady transonic small disturbance theory, and the effects of reduced frequency on first harmonic components of unsteady pressures due to airfoil pitching are among the topics covered. Author

N91-10850*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MORE ACCURATE PREDICTIONS WITH TRANSONIC NAVIER-STOKES METHODS THROUGH IMPROVED TURBULENCE MODELING
DENNIS A. JOHNSON *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 193-204 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Significant improvements in predictive accuracies for off-design conditions are achievable through better turbulence modeling; and, without necessarily adding any significant complication to the numerics. One well established fact about turbulence is it is slow to respond to changes in the mean strain field. With the 'equilibrium' algebraic turbulence models no attempt is made to model this characteristic and as a consequence these turbulence models exaggerate the turbulent boundary layer's ability to produce turbulent Reynolds shear stresses in regions of adverse pressure gradient. As a consequence, too little momentum loss within the boundary layer is predicted in the region of the shock wave and along the aft part of the airfoil where the surface pressure undergoes further increases. Recently, a 'nonequilibrium' algebraic turbulence model was formulated which attempts to capture this important characteristic of turbulence. This 'nonequilibrium' algebraic model employs an ordinary differential equation to model the slow response of the turbulence to changes in local flow conditions. In its original form, there was some question as to whether this 'nonequilibrium' model performed as well as the 'equilibrium' models for weak interaction cases. However, this turbulence model has since been further improved wherein it now appears that this turbulence model performs at least as well as the 'equilibrium' models for weak interaction cases and for strong interaction cases represents a very significant improvement. The performance of this turbulence model relative to popular 'equilibrium' models is illustrated for three airfoil test cases of the 1987 AIAA Viscous Transonic Airfoil Workshop, Reno, Nevada. A form of this 'nonequilibrium' turbulence model is currently being applied to wing flows for which similar improvements in predictive accuracy are being realized. Author

N91-10851*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RECENT ADVANCES IN RUNGE-KUTTA SCHEMES FOR SOLVING 3-D NAVIER-STOKES EQUATIONS
VEER N. VATSA, BRUCE W. WEDAN, and RIDHA ABID *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 207-221 Sep. 1989 Original contains color illustrations
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

A thin-layer Navier-Stokes has been developed for solving high Reynolds number, turbulent flows past aircraft components under transonic flow conditions. The computer code has been validated through data comparisons for flow past isolated wings, wing-body configurations, prolate spheroids and wings mounted inside wind-tunnels. The basic code employs an explicit Runge-Kutta time-stepping scheme to obtain steady state solution to the unsteady governing equations. Significant gain in the efficiency of the code has been obtained by implementing a multigrid acceleration technique to achieve steady-state solutions. The improved efficiency of the code has made it feasible to conduct grid-refinement and turbulence model studies in a reasonable amount of computer time. The non-equilibrium turbulence model of Johnson and King has been extended to three-dimensional flows and excellent agreement with pressure data has been obtained for transonic separated flow over a transport type of wing. Author

N91-10855*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CFD FOR APPLICATIONS TO AIRCRAFT AEROELASTICITY
GURU P. GURUSWAMY *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 271-286 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Strong interactions of structures and fluids are common in many engineering environments. Such interactions can give rise to physically important phenomena such as those occurring for aircraft due to aeroelasticity. Aeroelasticity can significantly influence the safe performance of aircraft. At present exact methods are available for making aeroelastic computations when flows are in either the linear subsonic or supersonic range. However, for complex flows containing shock waves, vortices and flow separations, computational methods are still under development. Several phenomena that can be dangerous and limit the performance of an aircraft occur due to the interaction of these complex flows with flexible aircraft components such as wings. For example, aircraft with highly swept wings experience vortex induced aeroelastic oscillations. Correct understanding of these complex aeroelastic phenomena requires direct coupling of fluids and structural equations. Here, a summary is presented of the development of such coupled methods and applications to aeroelasticity since about 1978 to present. The successful use of the transonic small perturbation theory (TSP) coupled with structures is discussed. This served as a major stepping stone for the current stage of aeroelasticity using computational fluid dynamics. The need for the use of more exact Euler/Navier-Stokes (ENS) equations for aeroelastic problems is explained. The current development of unsteady aerodynamic and aeroelastic procedures based on the ENS equations are discussed. Aeroelastic results computed using both TSP and ENS equations are discussed. Author

N91-10856*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF UNSTRUCTURED GRID METHODS TO STEADY AND UNSTEADY AERODYNAMIC PROBLEMS
JOHN T. BATINA *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 287-308 Sep. 1989 Original contains color illustrations
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The purpose is to describe the development of unstructured grid methods which have several advantages when compared to methods which make use of structured grids. Unstructured grids, for example, easily allow the treatment of complex geometries, allow for general mesh movement for realistic motions and structural deformations of complete aircraft configurations which is important for aeroelastic analysis, and enable adaptive mesh refinement to more accurately resolve the physics of the flow. Steady Euler calculations for a supersonic fighter configuration to demonstrate the complex geometry capability; unsteady Euler calculations for the supersonic fighter undergoing harmonic oscillations in a complete-vehicle bending mode to demonstrate

the general mesh movement capability; and vortex-dominated conical-flow calculations for highly-swept delta wings to demonstrate the adaptive mesh refinement capability are discussed. The basic solution algorithm is a multi-stage Runge-Kutta *time-stepping scheme with a finite-volume spatial discretization* based on an unstructured grid of triangles in 2D or tetrahedra in 3D. The moving mesh capability is a general procedure which models each edge of each triangle (2D) or tetrahedra (3D) with a spring. The resulting static equilibrium equations which result from a summation of forces are then used to move the mesh to allow it to continuously conform to the instantaneous position or shape of the aircraft. The adaptive mesh refinement procedure enriches the unstructured mesh locally to more accurately resolve the vortical flow features. These capabilities are described in detail along with representative results which demonstrate several advantages of unstructured grid methods. The applicability of the unstructured grid methodology to steady and unsteady aerodynamic problems and directions for future work are discussed. Author

N91-10857*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

GRID GENERATION AND INVISCID FLOW COMPUTATION ABOUT AIRCRAFT GEOMETRIES

ROBERT E. SMITH *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 311-326 Sep. 1989 Original contains color illustrations

Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Grid generation and Euler flow about fighter aircraft are described. A fighter aircraft geometry is specified by an area ruled fuselage with an internal duct, cranked delta wing or strake/wing combinations, canard and/or horizontal tail surfaces, and vertical tail surfaces. The initial step before grid generation and flow computation is the determination of a suitable grid topology. The external grid topology that has been applied is called a dual-block topology which is a patched C (exp 1) continuous multiple-block system where inner blocks cover the highly-swept part of a cranked wing or strake, rearward inner-part of the wing, and tail components. Outer-blocks cover the remainder of the fuselage, outer-part of the wing, canards and extend to the far field boundaries. The grid generation is based on transfinite interpolation with Lagrangian blending functions. This procedure has been applied to the Langley experimental fighter configuration and a modified F-18 configuration. Supersonic flow between Mach 1.3 and 2.5 and angles of attack between 0 degrees and 10 degrees have been computed with associated Euler solvers based on the finite-volume approach. When coupling geometric details such as boundary layer diverter regions, duct regions with inlets and outlets, or slots with the general external grid, imposing C (exp 1) continuity can be extremely tedious. The approach taken here is to patch blocks together at common interfaces where there is no grid continuity, but enforce conservation in the finite-volume solution. The key to this technique is how to obtain the information required for a conservative interface. The Ramshaw technique which automates the computation of proportional areas of two overlapping grids on a planar surface and is suitable for coding was used. Researchers generated internal duct grids for the Langley experimental fighter configuration independent of the external grid topology, with a conservative interface at the inlet and outlet. Author

N91-10858*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A ZONAL NAVIER-STOKES METHODOLOGY FOR FLOW SIMULATION ABOUT A COMPLETE AIRCRAFT

JOLEN FLORES *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 327-343 Sep. 1989 Original contains color illustrations

Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The thin layer, Reynolds-averaged, Navier-Stokes equations are used to simulate the transonic viscous flow about the complete F-16A fighter aircraft. These computations demonstrate how computational fluid dynamics can be used to simulate turbulent viscous flow about realistic aircraft geometries. A zonal grid approach is used to provide adequate viscous grid clustering on all aircraft surfaces. Zonal grids extend inside the F-16A inlet and up to the compressor face while power on conditions are modeled by employing a zonal grid extending from the exhaust nozzle to the far field. Computations are compared with existing experimental *data and are in fair agreement. Computations for the F-16A in* side slip are also presented. Author

N91-10859*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

NUMERICAL SIMULATION OF F-18 FUSELAGE FOREBODY FLOWS AT HIGH ANGLES OF ATTACK

LEWIS B. SCHIFF, RUSSELL M. CUMMINGS, REESE L. SORENSON, and YEHIA M. RIZK (Sterling Software, Palo Alto, CA.) *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 345-359 Sep. 1989

Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Fine-grid Navier-Stokes solutions were obtained for flow over the fuselage forebody and wing leading edge extension of the F/A-18 High Alpha Research Vehicle at large incidence. The resulting flows are complex, and exhibit cross flow separation from the sides of the forebody and from the leading edge extension. A well-defined vortex pattern is observed in the leeward-side flow. Results obtained for laminar flow show good agreement with flow visualizations obtained in ground-based experiments. Further, turbulent flows computed at high Reynolds-number flight-test conditions show good agreement with surface and off-surface visualizations obtained in flight. Author

N91-10860*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NAVIER-STOKES SOLUTIONS ABOUT THE F/A-18 FOREBODY-LEX CONFIGURATION

FARHAD GHAFFARI, JAMES M. LUCKRING, JAMES L. THOMAS, and BRENT L. BATES (Vigyan Research Associates, Inc., Hampton, VA.) *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 361-383 Sep. 1989 Original contains color illustrations

Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Three-dimensional viscous flow computations are presented for the F/A-18 forebody-LEX (Leading Edge EXtensions) geometry. Solutions are obtained from an algorithm for the compressible Navier-Stokes equations which incorporates an upwind-biased, flux-difference-splitting approach along with longitudinally-patched grids. Results are presented for both laminar and fully turbulent flow assumptions and include correlations with wind tunnel as well as flight-test results. A good quantitative agreement for the forebody surface pressure distribution is achieved between the turbulent computations and wind tunnel measurements at Mach number 0.6. The computed turbulent surface flow patterns on the forebody qualitatively agree well with in-flight surface flow patterns obtained on an F/A-18 aircraft at Mach number 0.34. Author

N91-10861*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

NAVIER-STOKES SOLUTIONS FOR FLOWS RELATED TO STORE SEPARATION

OKTAY BAYSAL (Old Dominion Univ., Norfolk, VA.), ROBERT L. STALLINGS, JR., and ELIZABETH B. PLENTOVICH *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 385-410 Sep. 1989 Original contains color illustrations

Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The objective is developing CFD capabilities to obtain solutions for viscous flows about generic configurations of internally and externally carried stores. The emphasis is placed on the supersonic flow regime with extensions being made to the transonic regime. The project is broken into four steps: (1) Cavity flows for internal carriage configurations; (2) High angle of attack flows, which may be experienced during the separation of the stores: (3) Flows about a body near a flat plate for external carriage configurations; and (4) Flows about a body inside or in the proximity of a cavity. Three-dimensional unsteady cavity flow solutions are obtained by an explicit, MacCormack algorithm, EMCAV3, for open, close, and

transitional cavities. High angle of attack flows past cylinders are solved by an implicit, upwind algorithm. All the results compare favorably with the experimental data. For flows about multiple body configurations, the Chimera embedding scheme is modified for finite-volume and multigrid algorithms, MaGGiE. Then a finite volume, implicit, upwind, multigrid Navier-Stokes solver which uses on overlapped/embedded and zonal grids, VUMXZ3, is developed from the CFL3D code. Supersonic flows past a cylinder near a flat plate are computed using this code. The results are compared with the experimental data. Currently the VUMXZ3 code is being modified to accomplish step 4 of this project. Wind tunnel experiments are also being conducted for validation purposes.
Author

N91-10862*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TRANAIR: RECENT ADVANCES AND APPLICATIONS
MICHAEL D. MADSON *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 411-427 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

TranAir is a computer code which solves the full-potential equation for transonic flow about very general and complex configurations. Piecewise flat surface panels are used to describe the surface geometry. This paneled definition is then embedded in an unstructured cartesian flow field grid. Finite elements are used in the discretization of the flow field grid in a manner which is fully conservative and second-order accurate. Since geometries may be defined with relative ease, and since the user is not involved in the generation of the flow field grid, computational results may be generated rather quickly for a wide range of geometries. For transonic cases in the cruise angle-of-attack range, TranAir has generated results which are in generally good agreement with both Euler results and wind tunnel data. A typical transonic case runs in 1 to 2 CPU hours on a Cray X-MP. For subcritical cases, the code runs in 15 to 30 CPU minutes, even for geometries in which several thousand surface panels are used in the definition. This ability to rapidly and accurately provide both subsonic and transonic predictions about very complex aircraft configurations gives TranAir the potential of being a very powerful and widely used design tool. Author

N91-10863*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NUMERICAL SIMULATION OF ROTORCRAFT
WILLIAM J. MCCROSKEY (Army Aviation Systems Command, Moffett Field, CA.) *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 431-446 Sep. 1989
Original contains color illustrations
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The objective of the research is to develop and validate accurate, user-oriented viscous CFD codes (with inviscid options) for three-dimensional, unsteady aerodynamic flows about arbitrary rotorcraft configurations. Unsteady, three-dimensional Euler and Navier-Stokes codes are developed, adapted, and extended to rotor-body combinations. Flow solvers are coupled with zonal grid topologies, including rotating and nonrotating blocks. Special grid clustering and wave-fitting techniques were developed to capture low-level radiating acoustic waves. Significant progress was made in computing the propagation of acoustic waves due to the interaction of a concentrated vortex and a helicopter airfoil. The need for higher-order schemes was firmly established in relatively inexpensive two-dimensional calculations. In three dimensions, the number of grid points required to capture the low-level acoustic waves becomes very large, so that large supercomputer memory becomes essential. Good agreement was obtained between the numerical results obtained with a thin-layer Navier-Stokes code and experimental data from a model rotor. In addition, several nonrotating configurations that are sometimes proposed to simulate rotor blade tips in conventional wind tunnels were examined, and the complex flow around the radical tip shape of the world's fastest helicopter is under investigation. These studies demonstrate the flexibility and power of CFD to gain physical insight, study novel ideas, and examine various possibilities that might be difficult or impossible to set up in physical experiments. As a prelude to studies of rotor-body aerodynamic interactions, a preliminary grid topology and moving-interface strategy were developed. A new Euler/Navier-Stokes code using these techniques computes the vortical wake directly, rather than modeling it, as in most previous rotorcraft studies. Several hover cases were run for conventional and advanced-geometry blades. Numerical schemes using multi-zones and/or adaptive grids appear to be necessary to simulate the complex vortical flows in rotor wakes. Author

N91-10864*# Sterling Federal Systems, Inc., Moffett Field, CA.
CALCULATION OF THE ROTOR INDUCED DOWNLOAD ON AIRFOILS
C. S. LEE *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 447-458 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

Interactions between the rotors and wing of a rotary wing aircraft in hover have a significant detrimental effect on its payload performance. The reduction of payload results from the wake of lifting rotors impinging on the wing, which is at 90 deg angle of attack in hover. This vertical drag, often referred as download, can be as large as 15 percent of the total rotor thrust in hover. The rotor wake is a three-dimensional, unsteady flow with concentrated tip vortices. With the rotor tip vortices impinging on the upper surface of the wing, the flow over the wing is not only three-dimensional and unsteady, but also separated from the leading and trailing edges. A simplified two-dimensional model was developed to demonstrate the stability of the methodology. The flow model combines a panel method to represent the rotor and the wing, and a vortex method to track the wing wake. A parametric study of the download on a 20 percent thick elliptical airfoil below a rotor disk of uniform inflow was performed. Comparisons with experimental data are made where the data are available. This approach is now being extended to three-dimensional flows. Preliminary results on a wing at 90 deg angle of attack in free stream is presented. Author

N91-10865*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THREE-DIMENSIONAL VISCOUS DRAG PREDICTION FOR ROTOR BLADES
CHING S. CHEN (National Academy of Sciences - National Research Council, Washington, DC.) *In its* NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 459-472 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The state-of-the-art in rotor blade drag prediction involves the use of two-dimensional airfoil tables to calculate the drag force on the blade. One of the most serious problems with the current methods is that they cannot be used for airfoils that have yet to be tested. Most of the drag prediction methods also do not take the Reynolds number or the rotational effects of the blade into account, raising doubts about the accuracy of the results. These problems are addressed with the development of an analytical method which includes the shape of airfoil, the effects of Reynolds number, and the rotational motion of the blade. Author

N91-10866*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROGRESS TOWARD THE DEVELOPMENT OF AN AIRFOIL ICING ANALYSIS CAPABILITY
MARK G. POTAPCZUK, COLIN S. BIDWELL, and BRIAN M. BERKOWITZ (Sverdrup Technology, Inc., Mayfield, OH.) *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 473-487 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

The NASA-Lewis aircraft icing analysis program is composed of three major sub-programs. These sub-programs are ice accretion simulation, performance degradation evaluation, and ice protection system evaluation. These topics cover all areas of concern related to the simulation of aircraft icing and its consequences. The motivation for these activities is twofold, reduction of time and

effort required in experimental programs and the ability to provide reliable information for aircraft certification in icing, over the complete range of environmental conditions. In addition to the analytical activities associated with development of these codes, several experimental programs are underway to provide verification information for existing codes. These experimental programs are also used to investigate the physical processes associated with ice accretion and removal for improvement of present analytical models. The NASA-Lewis icing analysis program is thus striving to provide a full range of analytical tools necessary for evaluation of the consequences of icing and of ice protection systems.
Author

N91-10867*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE BREAKUP OF TRAILING-LINE VORTICES
DAVID JACQMIN *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 489-494 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01/1

It is now known that Batchelor's trailing-line vortex is extremely unstable to small amplitude disturbances for swirl numbers in the neighborhood of 0.83. The results of numerical calculations are presented that show the response of the vortex in this range of swirl numbers to finite amplitude, temporal, helical disturbances. Phenomena observed include: (1) ejection of axial vorticity and momentum from the core resulting in the creation of secondary, separate vortices; (2) a great intensification of core axial vorticity and a weakening of core momentum; and (3) the production of azimuthal vorticity in the form of a tightly wrapped spiral wave. The second phenomenon eventually stablizes the vortex, which then smooths and gradually returns to an axisymmetric state. The calculations are mixed spectral-finite-difference, fourth-order accurate, and have been carried out at Reynolds numbers of 1000 to 2000. Some linearized results are also discussed in an attempt to explain the process of vortex intensification. Author

N91-10868*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA COMPUTATIONAL FLUID DYNAMICS CONFERENCE. VOLUME 2: SESSIONS 7-12
Sep. 1989 525 p Conference held at Moffett Field, CA, 7-9 Mar. 1989 Original contains color illustrations
(NASA-CP-10038-VOL-2; A-89160-VOL-2; NAS 1.55:10038-VOL-2) Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The objectives of the conference were to disseminate CFD research results to industry and university CFD researchers, to promote synergy among NASA CFD researchers, and to permit feedback from researchers outside of NASA on issues pacing the discipline of CFD. The focus of the conference was on the application of CFD technology but also included fundamental activities.

N91-10869*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPARATIVE STUDY OF NAVIER-STOKES CODES FOR HIGH-SPEED FLOWS
DAVID H. RUDY, JAMES L. THOMAS, AJAY KUMAR, PETER A. GNOFFO, and SUKUMAR R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA.) *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 3-18 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

A comparative study was made with four different codes for solving the compressible Navier-Stokes equations using three different test problems. The first of these cases was hypersonic flow through the P8 inlet, which represents inlet configurations typical of a hypersonic airbreathing vehicle. The free-stream Mach number in this case was 7.4. This 2-D inlet was designed to provide an internal compression ratio of 8. Initial calculations were made using two state-of-the-art finite-volume upwind codes, CFL3D and USA-PG2, as well as NASCRIN, a code which uses the unsplit finite-difference technique of MacCormack. All of these codes used the same algebraic eddy-viscosity turbulence model. In the experiment, the cowl lip was slightly blunted; however, for the computations, a sharp cowl leading edge was used to simplify the construction of the grid. The second test problem was the supersonic (Mach 3.0) flow in a three-dimensional corner formed by the intersection of two wedges with equal wedge angles of 9.48 degrees. The flow in such a corner is representative of the flow in the corners of a scramjet inlet. Calculations were made for both laminar and turbulent flow and compared with experimental data. The three-dimensional versions of the three codes used for the inlet study (CFL3D, USA-PG3, and SCRAMIN, respectively) were used for this case. For the laminar corner flow, a fourth code, LAURA, which also uses recently-developed upwind technology, was also utilized. The final test case is the two-dimensional hypersonic flow over a compression ramp. The flow is laminar with a free-stream Mach number of 14.1. In the experiment, the ramp angle was varied to change the strength of the ramp shock and the extent of the viscous-inviscid interaction. Calculations were made for the 24-degree ramp configuration which produces a large separated-flow region that extends upstream of the corner. Author

N91-10873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF CFD CODES FOR THE SIMULATION OF SCRAMJET COMBUSTOR FLOWFIELDS
TAWIT CHITSOMBOOM (Vigyan Research Associates, Inc., Hampton, VA.) and G. BURTON NORTHAM *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 75-89 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

An overview of CFD activities in the Hypersonic Propulsion Branch is given. Elliptic and PNS codes that are being used for the simulation of hydrogen-air combusting flowfields for scramjet applications are discussed. Results of the computer codes are shown in comparison with those of the experiments where applicable. Two classes of experiments will be presented: parallel injection of hydrogen into vitiated supersonic air flow; and normal injection of hydrogen into supersonic crossflow of vitiated air.
Author

N91-10881*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PREDICTION OF TURBINE ROTOR-STATOR INTERACTION USING NAVIER-STOKES METHODS
NATERI K. MADAVAN, MAN MOHAN RAI, and SHARAD GAVALI (Amdahl Corp., Sunnyvale, CA.) *In its* NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 205-216 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

Flows in turbomachinery are generally complex and do not easily lend themselves to numerical computation. The flows are three-dimensional and inherently unsteady. Complicated blade geometries and flow phenomena such as separation and periodic transition from laminar to turbulent flow add to the numerical complexity. Nevertheless, the accurate numerical analysis of such flows is a problem of considerable interest and practical importance to the turbomachinery community. Much of the early work in turbomachinery flow prediction focussed on airfoil cascades. While such analyses of flows in isolated airfoil rows have helped improve understanding of the flow phenomena and have gained widespread acceptance in the industrial community as a design tool, they do not yield any information regarding the unsteady effects arising out of rotor-stator aerodynamic interaction. These interaction effects become increasingly important as the distance between successive stator and rotor rows is decreased. Thus, the need exists for analytical tools that treat the rotor and stator airfoils as a system and provide information regarding the magnitude and the impact of the unsteady effects. The focus a three-dimensional, time-accurate, thin-layer Navier-Stokes code that was recently developed to study rotor-stator interaction problems. A system of patched and overlaid grids that move relative to each other is

used to discretize the flow field and the governing equations are integrated using a third-order upwind scheme set in an iterative, implicit framework. The code was used to simulate subsonic flow through an axial turbine configuration for which considerable experimental data exists. Grid refinement studies were also conducted as part of the code validation process. The current status of the research, along with planned future directions, are also discussed. Author

N91-10883*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AUTOMATED DESIGN OF CONTROLLED DIFFUSION BLADES
JOSE M. SANZ *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 231-244 Sep. 1989 Previously announced in IAA as A89-15967
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

A numerical automation procedure was developed to be used in conjunction with an inverse hodograph method for the design of controlled diffusion blades. With this procedure a cascade of airfoils with a prescribed solidity, inlet Mach No., inlet air flow angle and air flow turning can be produced automatically. The trailing edge thickness of the airfoil, an important quantity in inverse methods, is also prescribed. The automation procedure consists of a multi-dimensional Newton iteration in which the objective design conditions are achieved by acting on the hodograph input parameters of the underlying inverse code. The method, although more general in scope, is applied to the design of axial flow turbomachinery blade sections, both compressors and turbines. A collaborative effort with U.S. Engine Companies to identify designs of interest to the industry will be described. Author

N91-10886*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SIMULATION OF POWERED-LIFT FLOWS
WILLIAM R. VANDALSEM, KALPANA CHAWLA, KARLIN R. ROTH, MERRITT H. SMITH, KUDITIPUDI V. RAO, and THOMAS C. BLUM (Boeing Co., Seattle, WA.) *In its* NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 275-290 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The primary objective is to expose government, industry, and academic scientists to work underway at NASA-Ames towards the application of CFD to the powered lift area. One goal is to produce the technologies which will be required in the application of numerical techniques to, for example, the Supersonic STOVL program. The progress to date on the following specific projects is presented: Jet in ground effect with crossflow; Jet in a crossflow; Delta planform with multiple jets in ground effect; Integration of CFD with thermal and acoustic analyses; Improved flow visualization techniques for unsteady flows; YAV-8B Harrier simulation program; and E-7 simulation program. Author

N91-10887*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A NUMERICAL STUDY OF THE HOT GAS ENVIRONMENT AROUND A STOVL AIRCRAFT IN GROUND PROXIMITY
THOMAS J. VANOVERBEKE and JAMES D. HOLDEMAN *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 291-310 Sep. 1989 Previously announced in IAA as A88-48752 Original contains color illustrations
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The development of Short Takeoff Vertical Landing (STOVL) aircraft has historically been an empirical- and experienced-based technology. A 3-D turbulent flow CFD code was used to calculate the hot gas environment around an STOVL aircraft operating in ground proximity. Preliminary calculations are reported for a typical STOVL aircraft configuration to identify key features of the flow field, and to demonstrate and assess the capability of current 3-D CFD codes to calculate the temperature of the gases ingested at the engine inlet as a function of flow and geometric conditions. Author

N91-10888*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CFD ANALYSIS FOR HIGH SPEED INLETS
TOM BENSON *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 311-319 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The increased national interest in high speed flight has increased research for high speed propulsion components. The highly 3-D flows present in supersonic/hypersonic inlets are currently being studied at NASA-Lewis both experimentally and computationally using a family of steady Parabolized Navier-Stokes (PNS) and Navier-Stokes (NS) solvers and unsteady NS solvers. Some of the results of these efforts are presented with an emphasis on the comparison of the computational and experimental results. The flow in high speed inlets typically involves the interaction of compression shock waves and boundary layers on the internal surfaces. The fundamentals of these interactions have been studied experimentally for many years, while more recently, computations have been used to study these complex 3-D flow fields. Attempts to control the flow through boundary layer bleed are being investigated computationally prior to wind tunnel experiments. The ultimate goal is the higher performing inlets required for high speed flight. Author

N91-10889*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE USE OF A NAVIER-STOKES CODE IN THE WING DESIGN PROCESS
S. NAOMI MCMILLIN *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 321-342 Sep. 1989 Original contains color illustrations
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The feasibility was determined of incorporating the Navier-Stokes computational code, CFL3D, into the supersonic wing design process. The approach taken is of two steps. The first step was to calibrate CFL3D against existing experimental data sets obtained on thin sharp edged delta wings. The experimental data identified six flow types which are dependent on the similarity parameters of Mach number and angle of attack normal to the leading edge. The calibration showed CFL3D capable of simulating these various separated and attached flow conditions. The second step was to use CFL3D to study the initial formation of leading edge separation over delta wings at supersonic speeds. This consisted of examining solutions obtained on a 65 deg delta wing at Mach number of 1.6 with varying cross sectional shapes. Reynolds number was held constant at 1000000 and the Baldwin-Lomax turbulence model was used. The study showed that through the use of leading edge radius and/or camber, the onset of leading edge separation can be delayed to a higher angle of attack than observed on a flat sharp edged wing. Based on the geometries studied, three wind tunnel models are being designed to verify these results. Author

N91-10890*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATIONS OF A TRANSONIC WING DESIGN METHOD
RICHARD L. CAMPBELL and LEIGH A. SMITH *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 343-358 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

A method for designing wings and airfoils at transonic speeds using a predictor/corrector approach was developed. The procedure iterates between an aerodynamic code, which predicts the flow about a given geometry, and the design module, which compares the calculated and target pressure distributions and modifies the geometry using an algorithm that relates differences in pressure to a change in surface curvature. The modular nature of the design method makes it relatively simple to couple it to any analysis method. The iterative approach allows the design process and aerodynamic analysis to converge in parallel, significantly reducing the time required to reach a final design. Viscous and static aeroelastic effects can also be accounted for

during the design or as a post-design correction. Results from several pilot design codes indicated that the method accurately reproduced pressure distributions as well as the coordinates of a given airfoil or wing by modifying an initial contour. The codes were applied to supercritical as well as conventional airfoils, forward- and aft-swept transport wings, and moderate-to-highly swept fighter wings. The design method was found to be robust and efficient, even for cases having fairly strong shocks. Author

N91-10891*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AN EMBEDDED GRID FORMULATION APPLIED TO DELTA WINGS
JAMES L. THOMAS and SHERRIE L. KRIST (Vigyan Research Associates, Inc., Hampton, VA.) *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 361-377 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

An embedded grid algorithm for the Euler and/or Navier-Stokes equations is developed and applied to delta wings at high angles of attack in low speed flow. The Navier-Stokes code is an implicit, finite volume algorithm, using flux difference splitting for the convective and pressure terms and central differencing for the viscous and heat transfer terms. Calculations are compared with detailed experimental results over an angle of attack range up to and beyond the maximum lift coefficient, corresponding to vortex breakdown at the trailing edge, for a delta wing nominally of unit aspect ratio. The results indicate that the overall flowfield, including surface pressures, surface streamlines, and vortex trajectories, can be simulated accurately with the global grid version of the present algorithm. However, comparison of computed velocities and vorticity with experimentally measured off-body values at an angle of attack of 20.5 deg indicates the core region is substantially more diffuse in the computations than that measured with either a five-hole probe or a laser velocimeter. Embedded grids, used to improve the numerical discretization in the core region, are formulated within the framework of the implicit, upwind-biased multi-grid algorithm. Structured levels of local nested refinements are made. Three-dimensional results for both Euler and Navier-Stokes calculations are shown, with up to 3 levels of embedded refinement. The embedding procedure was effective in eliminating a crossflow secondary separation produced in the Euler solutions on coarse grids. Author

N91-10892*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
UNSTRUCTURED MESH SOLUTION OF THE EULER AND NAVIER-STOKES EQUATIONS
TIMOTHY J. BARTH *In its* NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 379-393 Sep. 1989
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

Mesh generation procedures as well as solution algorithms for solving the Euler and Navier-Stokes equations on unstructured meshes are presented. The solution algorithms discussed utilize approximate Riemann solver, upwind differencing to achieve high spatial accuracy. Numerical results for Euler flow over single and multi-element airfoils are presented. Author

N91-10893*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THREE DIMENSIONAL UNSTRUCTURED GRIDS FOR THE SOLUTION OF THE EULER EQUATIONS
CLYDE GUMBERT, P. PARIKH, S. PIRZADEH, and R. LOEHNER (George Washington Univ., Hampton, VA.) *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 2: Sessions 7-12 p 395-436 Sep. 1989
Original contains color illustrations
Avail: NTIS HC/MF A22; 30 functional color pages CSCL 01/1

The advancing front technique is being used to develop a code to generate grids around complex 3-D configurations for use in computing the invisid flow solutions by the Euler equations. By the advancing front technique points are introduced concurrently with the connectivity information so that a separate library is not required. The generation of a 3-D grid is accomplished in several steps. First the boundaries of the domain to be gridded must be described by two-, three- or four-sided surface patches. Next, a background mesh is required to control the grid spacing and stretching throughout the domain. This coarse tetrahedral grid is not required to conform to any of the boundaries. Next, each of the patches is mapped to 2-D, triangulated by the advancing front technique and mapped back to 3-D. These triangles form the initial front for the generation of the final tetrahedral mesh.
Author

N91-10902*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
PREDICTION OF EFFECTS OF WING CONTOUR MODIFICATIONS ON LOW-SPEED MAXIMUM LIFT AND TRANSONIC PERFORMANCE FOR THE EA-6B AIRCRAFT
DENNIS O. ALLISON and E. G. WAGGONER Washington Nov. 1990 48 p
(NASA-TP-3046; L-16741; NAS 1.60:3046) Avail: NTIS HC/MF A03 CSCL 01/1

Computational predictions of the effects of wing contour modifications on maximum lift and transonic performance were made and verified against low speed and transonic wind tunnel data. This effort was part of a program to improve the maneuvering capability of the EA-6B electronics countermeasures aircraft, which evolved from the A-6 attack aircraft. The predictions were based on results from three computer codes which all include viscous effects: MCARF, a 2-D subsonic panel code; TAWFIVE, a transonic full potential code; and WBPPW, a transonic small disturbance potential flow code. The modifications were previously designed with the aid of these and other codes. The wing modifications consists of contour changes to the leading edge slats and trailing edge flaps and were designed for increased maximum lift with minimum effect on transonic performance. The prediction of the effects of the modifications are presented, with emphasis on verification through comparisons with wind tunnel data from the National Transonic Facility. Attention is focused on increments in low speed maximum lift and increments in transonic lift, pitching moment, and drag resulting from the contour modifications.
Author

N91-10904*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONICAL EULER SIMULATION AND ACTIVE SUPPRESSION OF DELTA WING ROCKING MOTION
ELIZABETH M. LEE and JOHN T. BATINA Oct. 1990 34 p
(NASA-TM-102683; NAS 1.15:102683) Avail: NTIS HC/MF A03 CSCL 01/1

A conical Euler code was developed to study unsteady vortex-dominated flows about rolling highly-swept delta wings, undergoing either forced or free-to-roll motions including active roll suppression. The flow solver of the code involves a multistage Runge-Kutta time-stepping scheme which uses a finite volume spatial discretization of the Euler equations on an unstructured grid of triangles. The code allows for the additional analysis of the free-to-roll case, by including the rigid-body equation of motion for its simultaneous time integration with the governing flow equations. Results are presented for a 75 deg swept sharp leading edge delta wing at a freestream Mach number of 1.2 and at alpha equal to 10 and 30 deg angle of attack. A forced harmonic analysis indicates that the rolling moment coefficient provides: (1) a positive damping at the lower angle of attack equal to 10 deg, which is verified in a free-to-roll calculation; (2) a negative damping at the higher angle of attack equal to 30 deg at the small roll amplitudes. A free-to-roll calculation for the latter case produces an initially divergent response, but as the amplitude of motion grows with time, the response transitions to a wing-rock type of limit cycle oscillation. The wing rocking motion may be actively suppressed, however, through the use of a rate-feedback control law and antisymmetrically deflected leading edge flaps. The descriptions of the conical Euler flow solver and the free-to-roll analysis are presented. Results are also presented which give

insight into the flow physics associated with unsteady vortical flows about forced and free-to-roll delta wings, including the active roll suppression of this wing-rock phenomenon. Author

N91-10906 Colorado Univ., Boulder.
COMPUTATION OF TRANSONIC FLOW OVER ELASTIC ROTOR BLADE Ph.D. Thesis
LIE-MINE GEA 1989 121 p
Avail: Univ. Microfilms Order No. DA9024828

The understanding of the aeroelastic behavior of transonic rotor blades is essential in the design of advanced vertical-takeoff and landing vehicles such as the tilt-rotor and x-wing aircraft. A computational tool is developed by coupling an aerodynamic code with a structural dynamic code, which can be used to predict the performance of an elastic rotor blade when operating at transonic speeds. The full-potential transonic rotor flow code TFAR2, based on the finite-difference approach, is used to compute the inviscid, isentropic, and irrotational flow field in a blade-fixed coordinate system. On the other hand, the finite-element approach based on beam theory is employed in the structural dynamic code. Flutter equations are solved in time domain instead of in frequency domain of using modal analysis, and a global-local transformation matrix is derived to improve the accuracy for large blade deflections. The computer natural frequencies of a modal blade in the first five modes (three flapping, one lagging, and one torsion) agree very well with experimental data. To demonstrate the capability of this computational tool, both hovering and forward flight cases for the model blade are examined. Numerical results are presented separately to show the differences between rigid and elastic blade calculations. The comparison reveals that the blade elasticity plays an important role in the transonic regime, especially when the rotor is in forward flight. Dissert. Abstr.

N91-10907 Colorado Univ., Boulder.
EXPERIMENTAL INVESTIGATION OF THE MECHANISMS UNDERLYING VORTEX KINEMATICS IN UNSTEADY SEPARATED FLOWS Ph.D. Thesis
SCOTT JEFFREY SCHRECK 1989 155 p
Avail: Univ. Microfilms Order No. DA9024868

Current research in the area of unsteady separated flows has been strongly motivated by potential enhancements to air vehicle performance. Dynamic motions of lifting surfaces give rise to the emergence and fleeting presence of energetic, large-scale vortical structures characteristic of unsteady separated flow fields. While present over the lifting surface, these vortices substantially augment lift and moment coefficients and exact only modest penalties in terms of elevated drag coefficients. However, the feasibility of utilizing unsteady separation relies upon thorough comprehension of the fluid dynamic mechanisms responsible for vortex presence and behavior. To date, these mechanisms remain relatively obscure. Unsteady separated flow fields in the vicinity of a flat plate oscillating sinusoidally in pitch about the quarterchord were investigated for a broad range of pitching parameters. Phase locked photograph of smoke flow visualization was employed in conjunction with hotwire anemometry to quantify vortex development as well as some of the primary boundary layer interactions contributing to the observed vortex kinematics. Leading edge vortex development was strongly influenced by both the freestream and boundary layer flows. These and other observations facilitated formulation of a conceptual model which accounts for many of these observations. Quantitative refinement of such a model is one methodology through which unsteady separation may eventually be understood, predicted, and controlled for employment in future air vehicles. Dissert. Abstr.

N91-10908 Princeton Univ., NJ.
NONOVERLAPPING COMPOSITE MESHES FOR MULTI-ELEMENT AIR-FOILS Ph.D. Thesis
MARK ERIC MICHAEL STEWART 1990 157 p
Avail: Univ. Microfilms Order No. DA9024542

Developing the ability to place grids for numerical calculations in geometrically complex regions is a problem of current interest in many engineering and scientific disciplines. Its importance arises because grid generation is a prominent limitation in computational problems involving complex geometries. One direction of grid generation research is the multiblock approach where the domain is decomposed into simple, non-overlapping sub-regions. Multiblock grids for non-trivial, three-dimensional aircraft configurations with solutions have been generated in the past. Yet, the procedures used are not automatic, and require substantial human intervention to determine the overall block structure, and grid point distribution. Automation of this procedure is necessary before these methods can come into common usage. A novel algorithm was developed and investigated for substantially automating the decomposition of arbitrary two-dimensional domains into non-overlapping, topologically rectangular blocks. To demonstrate the technique, solutions to the Euler equations for several multi-element airfoil configurations are presented, including a four element landing configuration. Further, accuracy estimates for the grids are developed analytically, and approximated numerically to demonstrate the accuracy characteristics of the singularities which occur in the grids. Dissert. Abstr.

N91-10910 North Carolina State Univ., Raleigh.
AERODYNAMIC INTERACTION OF COUNTER ROTATING PROPELLERS Ph.D. Thesis
YOONSANG LEE 1989 81 p
Avail: Univ. Microfilms Order No. DA9017689

Axial and circumferential flow velocity components were measured at discrete points between rotors of a 28 cm diameter counter rotating propeller using both a single and a two-component hot-film anemometer. The tests were performed in an open-jet anechoic wind tunnel with a 0.61 m x 0.61 m square nozzle and a free-stream speed of 0.09 Mach number. Primary test variables were radial and axial positions of the hot-film sensor and rotor-to-rotor spacing of the CRP. Axial flow measurements from a single sensor agreed well with those of a two-component X-probe. Single sensor and X-probe measurements of circumferential flow did not agree as well. Axial mean flow data show significant upstream influence of the aft rotor. The circumferential mean flow between rotors appears relatively uninfluenced by the aft rotor. Turbulence intensity abruptly increased near the blade tip suggesting a possible tip vortex from the forward rotor. Turbulence intensity decreased between rotors as rotor-to-rotor spacing increased. The analysis was extended to determine the velocity fluctuations at the blade passing frequencies and the blade interaction frequency. Velocity fluctuation at each of these discrete frequencies were observed, including the forward-aft rotor interaction frequencies. Dissert. Abstr.

N91-10913 George Washington Univ., Washington, DC.
EJECTOR THRUST AUGMENTORS: PULSE-STARTING APPROACH TO THE SECOND SOLUTION Ph.D. Thesis
MOHAMED AHMED ABDEL-WAHAB 1990 156 p
Avail: Univ. Microfilms Order No. DA9020742

While the steady flow supersonic solution to the ejector problem has been studied analytically, experimental validation has been elusive. Lack of validation may be explained by the possibility that localized processes may violate the second law of thermodynamics even though there is no overall violation. To detect the process mechanism, a pulse-starting simulation, analogous to the one used to analyze supersonic and hypersonic shock tunnels, was used to analyze the dynamics of the ejector. Compared to the steady flow CFD approach, this method greatly reduces the uncertainties associated with simulating mixing processes. The computation analysis used can reveal local violation of the second law of thermodynamics that cannot be detected by control volume analysis and that would rule out a second solution even when the associated overall entropy increment is positive. Analysis also reveals important details of the mechanism by which momentum and energy are exchanged in flow induction devices operating on the basis of wave processes. To illustrate the application of the proposed method, the method of analysis was applied to a specific set of boundary conditions that would, according to control volume analysis, lead to a second solution only marginally permitted by the second law. Analysis is performed until the front of the

advancing flow is a substantially normal shock. The study validates the analysis and its conclusions for one case by a double-flow shock tube experiment. Dissert. Abstr.

N91-10915 Oxford Univ. (England).
THE AERODYNAMIC EFFECTS OF NOZZLE GUIDE VANE SHOCK WAVE AND WAKE PASSING ON A TRANSONIC TURBINE ROTOR Ph.D. Thesis
A. B. JOHNSON 1988 233 p
Avail: Univ. Microfilms Order No. BRD-89420

Flow perturbations are intrinsic in the operation of any turbine and are often associated with the periodic chopping of the wakes from an upstream blade row by the next row. The effect of these perturbations on the aerodynamic performance of the passage, the thermal loading of the blades and the blade profile losses needs to be understood. An experimental study of some of these effects was made using a nozzle guide vane wake and trailing edge shock wave simulator. Measurements of time resolved and time averaged surface pressures and heat transfer rates were made, together with schlieren photography flow visualization tests. This was supported by tests made in a 9x3 inch induced flow transonic tunnel to examine the characteristics of the wakes and shock waves being tested by the simulation. The results were used to study the propagation of the shock waves and wakes through the rotor passage. Shock wave passing was shown to nucleate a vortex and separation bubble at the leading edge of the blade and cause a novel shock wave pressure surface interaction. The interaction between the shock wave and blade boundary layer can cause large, rapid fluctuations in the surface heat transfer rate, and a negative heat transfer rate in some cases. A theoretical model was proposed to explain this phenomenon. The passing of the wake over the pressure surface was shown to cause both positive and negative fluctuations in the surface heat transfer rate. Two computational fluid dynamics codes were tested to predict the steady and unsteady flows. A sensitivity to the effects of surface discontinuities was identified in one code. The results were compared with those found in the equivalent experimental tests with very good agreement. Dissert. Abstr.

N91-10916 Illinois Univ. at Urbana-Champaign, Savoy.
NUMERICAL CALCULATIONS FOR FLOWS PAST AN UNCONVENTIONAL AIRFOIL Ph.D. Thesis
PING-HO TSAI 1990 122 p
Avail: Univ. Microfilms Order No. DA9021770

A computer program was developed for both 2-D compressible and incompressible turbulent flows around airfoils. Numerical solutions were obtained by solving the steady state Reynolds-averaged Navier-Stokes equations in primitive variable form. The standard k-epsilon turbulence model was employed and a compression turbulence model was also discussed. Based on a non-staggered arrangement on a body-fitted grid system, the discretized transport equations were solved either by a hybrid or a second-order upwind differencing scheme. A multiple pressure correction procedure with implicit density treatment was used. The solutions were obtained through an under-relaxed iterative process. Various cases of flow past NACA 0012 and 4412 airfoils were examined first. The results were good when compared with experimental data. Many cases of incompressible and compressible flows past an unconventional airfoil were then computed. The general behavior of the unconventional airfoil is presented.
Dissert. Abstr.

N91-10918*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IMPLICIT FLUX-SPLIT EULER SCHEMES FOR UNSTEADY AERODYNAMIC ANALYSIS INVOLVING UNSTRUCTURED DYNAMIC MESHES
JOHN T. BATINA Nov. 1990 11 p Presented at the 31st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Long Beach, CA, 2-4 Apr. 1990 Previously announced in IAA as A90-29362
(NASA-TM-102732; NAS 1.15:102732; AIAA-90-0936) Avail: NTIS HC/MF A03 CSCL 01/1

Improved algorithm for the solution of the time-dependent Euler equations are presented for unsteady aerodynamic analysis involving unstructured dynamic meshes. The improvements were developed recently to the spatial and temporal discretizations used by unstructured grid flow solvers. The spatial discretization involves a flux-split approach which is naturally dissipative and captures shock waves sharply with at most one grid point within the shock structure. The temporal discretization involves an implicit time-integration scheme using a Gauss-Seidel relaxation procedure which is computationally efficient for either steady or unsteady flow problems. For example, very large time steps may be used for rapid convergence to steady state, and the step size for unsteady cases may be selected for temporal accuracy rather than for numerical stability. Steady and unsteady flow results are presented for the NACA 0012 airfoil to demonstrate applications of the new Euler solvers. The unsteady results were obtained for the airfoil pitching harmonically about the quarter chord. The resulting instantaneous pressure distributions and lift and moment coefficients during a cycle of motion compare well with experimental data. A description of the Euler solvers is presented along with results and comparisons which assess the capability. Author

N91-10919*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TEMPORAL-ADAPTIVE EULER/NAVIER-STOKES ALGORITHM FOR UNSTEADY AERODYNAMIC ANALYSIS OF AIRFOILS USING UNSTRUCTURED DYNAMIC MESHES
WILLIAM L. KLEB, JOHN T. BATINA, and MARC H. WILLIAMS (Purdue Univ., West Lafayette, IN.) Nov. 1990 10 p Presented at the 21st AIAA Fluid Dynamics, Plasma Dynamics, and Lasers Conference, Seattle, WA, 18-20 Jun. 1990 Previously announced in IAA as A90-38778
(NASA-TM-102734; NAS 1.15:102734; AIAA-90-1650) Avail: NTIS HC/MF A02 CSCL 01/1

A temporal adaptive algorithm for the time-integration of the two-dimensional Euler or Navier-Stokes equations is presented. The flow solver involves an upwind flux-split spatial discretization for the convective terms and central differencing for the shear-stress and heat flux terms on an unstructured mesh of triangles. The temporal adaptive algorithm is a time-accurate integration procedure which allows flows with high spatial and temporal gradients to be computed efficiently by advancing each grid cell near its maximum allowable time step. Results indicate that an appreciable computational savings can be achieved for both inviscid and viscous unsteady airfoil problems using unstructured meshes without degrading spatial or temporal accuracy. Author

N91-10920# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
CONTRIBUTIONS IN THE FIELD OF AEROELASTICS ON THE OCCASION OF THE 60TH ANNIVERSARY OF PROFESSOR DR.-ING. HABIL. HANS WILHELM FOERSCHING [BEITRAEGE AUS DEM BEREICH DER AEROELASTIK ZUM 60. GEBURTSTAG VON PROFESSOR DR.-ING. HABIL. HANS WILHELM FOERSCHING]
Apr. 1990 287 p In ENGLISH and GERMAN
(ETN-90-97630) Avail: NTIS HC/MF A13

A numerical procedure for the calculation of unsteady transonic flow about oscillating airfoils is presented. The status of stuctural dynamics qualification of spacecraft is depicted. Aeroelastics and dynamics of wind turbines are treated. The structural analysis and optimization of a propfan blade were studied using the finite element method. The derivative balance for a transonic wind tunnel was designed. The pressure distribution on an oscillating airfoil in incompressible flow was calculated. Unsteady aerodynamic forces on engines were determined with a view to flutter investigations. Unsteady wind tunnel wall interferences in subsonic and transonic profile flows were studied theoretically. Adaptive digital real time filtering in strutural dynamics was investigated. The nonlinear vibration of large, imperfect space structures was studied.

N91-10921# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
THE CALCULATION OF UNSTEADY COMPRESSIBLE FLOW ABOUT OSCILLATING AIRFOIL PROFILES USING THE EULER UPWIND METHOD [DIE BERECHNUNG VON INSTATIONAEREN KOMPRESSIBLEN STROEMUNGEN UM SCHWINGENDE PROFILE MIT HILFE EINES EULER-UPWIND-VERFAHRENS]
VOLKER CARSTENS *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 13-38 Apr. 1990 In GERMAN; ENGLISH summary
Avail: NTIS HC/MF A13

A numerical procedure for the calculation of the unsteady transonic flow about oscillating airfoils, based on the Euler equations in conservative form is presented. The selected solution method, called flux vector splitting, is similar to a characteristic method, and is characterized by the use of spatially one sided differences (upwinding). This method has a good numerical stability and excellent shock capturing properties. The wall boundary conditions at the profile surface, and, in the case of unsteady flow, the nonreflecting boundary conditions at the outer grid boundary were implemented in a numerical algorithm. The close agreement between numerical results and experimental data is illustrated by an AGARD standard test case. Numerical results for reduced frequencies give an impression of the influence of the reduced frequency on unsteady pressure and lift. ESA

N91-10926# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
CALCULATION OF THE PRESSURE DISTRIBUTION ON AN *OSCILLATING AIRFOIL IN INCOMPRESSIBLE FLOW* CONSIDERING NONLINEAR EFFECTS Ph.D. Thesis
LORENZ TICHY *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 127-139 Apr. 1990
Avail: NTIS HC/MF A13

Panel methods were used to calculate the pressure on a two dimensional airfoil which performs harmonic plunging and pitching oscillations in an incompressible potential flow. Two panel methods are described which allow the examination of the influence of profile and wake geometries on pressure distribution and aerodynamic coefficients. The first method operates in the frequency domain; it only takes into account the nonlinear influences resulting from the slope of the airfoil contour (i.e., from airfoil thickness and angle of attack). The second method is applicable in the time domain; it provides a more exact description of the wake geometry. Comparisons of the results from both methods with the linear flat plate solution demonstrate the significance of the above mentioned influences. ESA

N91-10933*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE CALCULATION OF ROTOR/FUSELAGE INTERACTION FOR TWO-DIMENSIONAL BODIES
PAUL M. STREMEL Aug. 1990 35 p Presented at the 16th European Rotorcraft Forum, Glasgow, Scotland, 18-21 Sep. 1990 (NASA-TM-102855; A-90256; NAS 1.15:102855) Avail: NTIS HC/MF A03 CSCL 01/1

Unsteady rotor wake interactions with the empennage, tail boom, and other aerodynamic surfaces have a significant influence on the aerodynamic performance of the helicopter, ride quality, and vibration. A Computational Fluid Dynamic (CFD) method for computing the aerodynamic interaction between an interacting vortex wake and the viscous flow about arbitrary 2-D bodies was developed to address this helicopter problem. The vorticity and flow field velocities are calculated on a body-fitted computational mesh using an uncoupled iterative solution. The interacting vortex wake is represented by an array of discrete vortices which, in turn, are represented by a finite core model. The evolution of the interacting vortex wake is calculated by Lagrangian techniques. The flow around circular and elliptic cylinders in the absence of an interacting vortex wake was calculated. These results compare very well with other numerical results and with results obtained from experiment and thereby demonstrate the accuracy of the viscous solution. The interaction of a simulated rotor wake with the flow about 2-D bodies, representing cross sections of fuselage components, was calculated to address the vortex interaction problem. The vortex interaction was calculated for the flow about a circular and an elliptic cylinder at 45 and 90 degrees incidence. The results demonstrate the significant variation in lift and drag on the 2-D bodies during the vortex interaction. Author

N91-10934*# Stanford Univ., CA. Dept. of Aeronautics and Astronautics.
A NUMERICAL STUDY OF THE EFFECTS OF WIND TUNNEL WALL PROXIMITY ON AN AIRFOIL MODEL
MARK POTSDAM and LEONARD ROBERTS Sep. 1990 72 p (Contract NCC2-055)
(NASA-CR-187322; NAS 1.26:187322; JIAA-TR-99) Avail: NTIS HC/MF A04 CSCL 01/1

A procedure was developed for modeling wind tunnel flows using computational fluid dynamics. Using this method, a numerical study was undertaken to explore the effects of solid wind tunnel wall proximity and Reynolds number on a two-dimensional airfoil model at low speed. Wind tunnel walls are located at varying wind tunnel height to airfoil chord ratios and the results are compared with freestream flow in the absence of wind tunnel walls. Discrepancies between the constrained and unconstrained flows can be attributed to the presence of the walls. Results are for a Mach Number of 0.25 at angles of attack through stall. A typical wind tunnel Reynolds number of 1,200,000 and full-scale flight Reynolds number of 6,000,000 were investigated. At this low Mach number, wind tunnel wall corrections to Mach number and angle of attack are supported. Reynolds number effects are seen to be a consideration in wind tunnel testing and wall interference correction methods. An unstructured grid Navier-Stokes code is used with a Baldwin-Lomax turbulence model. The numerical method is described since unstructured flow solvers present several difficulties and fundamental differences from structured grid codes, especially in the area of turbulence modeling and grid generation. Author

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A91-10959
TWENTY YEARS OF CONCORDE - THE EXPERIENCE OF AIR FRANCE [VINGT ANS DE CONCORDE - L'EXPERIENCE D'AIR FRANCE]
PIERRE KLEITZ (Air France, Paris) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 85-89. In French.
Copyright

The technical, commercial and economic aspects of Air France's operational experience with the Concorde are presented. From the technical point of view engine reliability from both the operational and maintenance aspects is less than that for conventional aircraft though dispatch reliability has been satisfactory. Fuel consumption and total operating cost have been high however, some commercial profitability has been achieved. Specific noise abatement procedures in supersonic flight and around airports forced severe operational restrictions including subsonic cruise limitations over populated areas. It is concluded that the Concorde experience has resulted in valuable operational and technical experience that will prove useful in future SST commercial transport designs. R.E.P.

A91-10960
BRITISH AIRWAYS OPERATIONAL EXPERIENCE WITH CONCORDE
DAVID A. MACDONALD (British Airways, PLC, London, England) IN: *European Symposium on the Future of High Speed Air* Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 90-94.
Copyright

Since 1976 British Airways has operated Concorde aircraft on a variety of routes. During that period more supersonic operating experience than any other organization has been accumulated, to a total of more than 80,000 flying hours. The key to Concorde's success, however, has been in the marketplace where its unique capabilities have ensured a niche against which there is currently no real competition. With thirty four scheduled and many charter services operated each week perhaps the greatest challenge will be maintaining the integrity of operation as the aircraft progresses into the later stages of its life. Author

N91-10028# Federal Aviation Administration, Long Beach, CA. Northwest Mountain Region.
SEAT DYNAMIC PERFORMANCE STANDARDS FOR A RANGE OF SIZES
STEPHEN SOLTIS Aug. 1990 27 p
(DOT/FAA/CT-TN90/23) Avail: NTIS HC/MF A03

A summary is presented of the rationale that was used to determine the crash impact characteristics for a range of aircraft sizes and places emphasis on developing seat dynamic performance standards that might be used for commuter category size aircraft. The existing crash dynamics data base which includes twin engine general aviation aircraft, rotorcraft, narrow body and wide body transport aircraft were used in this study. The crash impact characteristic of typical airframe structure will be related to the geometric size of the airframe. Author

N91-10029# Federal Aviation Administration, Atlantic City, NJ.
TESTS OF THE GENERAL FIRE SUPPRESSION CONCENTRATE PYROCAP B-136
GEORGE B. GEYER, JOSEPH A. WRIGHT, DUNG DO, and LAWRENCE HAMPTON Aug. 1990 34 p
(DOT/FAA/CT-TN90/21) Avail: NTIS HC/MF A03

Fire extinguishing effectiveness of the general fire suppression concentrate identified as Pyrocap B-136 was determined by laboratory experiments and large-scale fire tests. This agent demonstrated strong emulsifying properties toward Jet A (kerosene fuel), JP-4 (kerosene and gasoline fuel blend), and avgas (aviation gasoline fuel). At 6 percent concentration, Pyrocap B-136 extinguished large Jet A fuel fires when applied at the rate of 0.052 gallon per minute per square foot. At 30 percent concentration, the agent was effective in extinguishing magnesium aircraft wheel fires at a low application rate. Author

N91-10936*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AVIATION SAFETY/AUTOMATION PROGRAM CONFERENCE
SAMUEL A. MORELLO, comp. Washington Oct. 1990 270 p Conference held in Virginia Beach, VA, 11-12 Oct. 1989
(NASA-CP-3090; L-16840; NAS 1.55:3090) Avail: NTIS HC/MF A12 CSCL 01/3

The Aviation Safety/Automation Program Conference - 1989 was sponsored by the NASA Langley Research Center on 11 to 12 October 1989. The conference, held at the Sheraton Beach Inn and Conference Center, Virginia Beach, Virginia, was chaired by Samuel A. Morello. The primary objective of the conference was to ensure effective communication and technology transfer by providing a forum for technical interchange of current operational problems and program results to date. The Aviation Safety/Automation Program has as its primary goal to improve the safety of the national airspace system through the development and integration of human-centered automation technologies for aircraft crews and air traffic controllers.

N91-10941*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AVIATION SAFETY/AUTOMATION PROGRAM OVERVIEW
SAMUEL A. MORELLO *In its* Aviation Safety/Automation Program *Conference* p 67-73 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

The goal is to provide a technology base leading to improved safety of the national airspace system through the development and integration of human-centered automation technologies for aircraft crews and air traffic controllers. Information on the problems, specific objectives, human-automation interaction, intelligent error-tolerant systems, and air traffic control/cockpit integration is given in viewgraph form. Author

N91-10946*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ASSESSING INFORMATION TRANSFER IN FULL MISSION FLIGHT SIMULATIONS
ALFRED T. LEE *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 127-130 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Considerable attention must be given to the important topic of aircrew situation awareness in any discussion of aviation safety and flight deck design. Reliable means of assessing this important aspect of crew behavior without simultaneously interfering with the behavior are difficult to develop. Unobtrusive measurement of crew situation awareness is particularly important in the conduct of full mission simulations where considerable effort and cost is expended to achieve a high degree of operational fidelity. An unobtrusive method of assessing situational awareness is described here which employs a topical analysis of intra-crew communications. The communications were taken from videotapes of crew behavior prior to, during, and following an encounter with a microburst/windshear event. The simulation scenario re-created an actual encounter with an event during an approach into Denver Stapleton Airport. The analyses were conducted on twelve experienced airline crews with the objective of determining the effect on situation awareness of uplinking ground-based information of the crew during the approach. The topical analysis of crew communication was conducted on all references to weather or weather-related topics. The general weather topic was further divided into weather subtopical references such as surface winds, windshear, precipitation, etc., thereby allowing for an assessment of the relative frequency of subtopic reference during the scenario. Reliable differences were found between the relative frequency of subtopic references when comparing the communications of crews receiving a cockpit display of ground-based information to the communications of a control group. The findings support the utility of this method of assessing situation awareness and information value in full mission simulations. A limiting factor in the use of this measure is that crews vary in the amount of intra-crew communications that may take place due to individual differences and other factors associated with crew coordination. This factor must be taken into consideration when employing this measure. Viewgraphs are given. Author

N91-10951*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FAULT DIAGNOSIS
KATHY ABBOTT *In its* Aviation Safety/Automation Program Conference p 165-174 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

The objective of the research in this area of fault management is to develop and implement a decision aiding concept for diagnosing faults, especially faults which are difficult for pilots to identify, and to develop methods for presenting the diagnosis information to the flight crew in a timely and comprehensible manner. The requirements for the diagnosis concept were identified by interviewing pilots, analyzing actual incident and accident cases, and examining psychology literature on how humans perform diagnosis. The diagnosis decision aiding concept developed based on those requirements takes abnormal sensor readings as input, as identified by a fault monitor. Based on these abnormal sensor

readings, the diagnosis concept identifies the cause or source of the fault and all components affected by the fault. This concept was implemented for diagnosis of aircraft propulsion and hydraulic subsystems in a computer program called Draphys (Diagnostic Reasoning About Physical Systems). Draphys is unique in two important ways. First, it uses models of both functional and physical relationships in the subsystems. Using both models enables the diagnostic reasoning to identify the fault propagation as the faulted system continues to operate, and to diagnose physical damage. Draphys also reasons about behavior of the faulted system over time, to eliminate possibilities as more information becomes available, and to update the system status as more components are affected by the fault. The crew interface research is examining display issues associated with presenting diagnosis information to the flight crew. One study examined issues for presenting system status information. One lesson learned from that study was that pilots found fault situations to be more complex if they involved multiple subsystems. Another was pilots could identify the faulted systems more quickly if the system status was presented in pictorial or text format. Another study is currently under way to examine pilot mental models of the aircraft subsystems and their use in diagnosis tasks. Future research plans include piloted simulation evaluation of the diagnosis decision aiding concepts and crew interface issues. Information is given in viewgraph form. Author

N91-10952*# BBN Systems and Technologies Corp., Cambridge, MA.

FAULT RECOVERY RECOMMENDATION

EVA HUDLICKA and KEVIN CORKER *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 175-185 Oct. 1990

Avail: NTIS HC/MF A12 CSCL 01/3

Information on Recovery Recommendation System (RECORS) is given in viewgraph form. The system goal is to provide intelligent aiding for monitoring, diagnosis and response to aircraft system failures. Information is given on levels of abstraction, RECORS implementation, and architecture. Author

N91-10953*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A FUNCTION-BASED APPROACH TO COCKPIT PROCEDURE AIDS

ANIL V. PHATAK, PARVEEN JAIN (Expert-EASE Systems, Inc., Belmont, CA.), and EVERETT PALMER *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 187-197 Oct. 1990

Avail: NTIS HC/MF A12 CSCL 01/3

The objective of this research is to develop and test a cockpit procedural aid that can compose and present procedures that are appropriate for the given flight situation. The procedure would indicate the status of the aircraft engineering systems, and the environmental conditions. Prescribed procedures already exist for normal as well as for a number of non-normal and emergency situations, and can be presented to the crew using an interactive cockpit display. However, no procedures are prescribed or recommended for a host of plausible flight situations involving multiple malfunctions compounded by adverse environmental conditions. Under these circumstances, the cockpit procedural aid must review the prescribed procedures for the individual malfunction (when available), evaluate the alternatives or options, and present one or more composite procedures (prioritized or unprioritized) in response to the given situation. A top-down function-based conceptual approach towards composing and presenting cockpit procedures is being investigated. This approach is based upon the thought process that an operating crew must go through while attempting to meet the flight objectives given the current flight situation. In order to accomplish the flight objectives, certain critical functions must be maintained during each phase of the flight, using the appropriate procedures or success paths. The viability of these procedures depends upon the availability of required resources. If resources available are not sufficient to meet the requirements, alternative procedures (success paths) using the available resources must be constructed to maintain the critical functions and the corresponding objectives. If no success path exists that can satisfy the critical functions/objectives, then the next level of critical functions/objectives must be selected and the process repeated. Information is given in viewgraph form. Author

N91-10955*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INFLIGHT REPLANNING FOR DIVERSIONS

MICHAEL PALMER *In its* Aviation Safety/Automation Program Conference p 209-218 Oct. 1990

Avail: NTIS HC/MF A12 CSCL 01/3

Current procedures for handling flight plan diversions can require too much of the crew's resources. This increases workload and may compromise safety and cause delays in modifying the flight plan. The goal of NASA Langley Research Center's Diverter research program is to develop guidelines for a prototype pilot decision aid for diversions that will reduce cognitive workload, improve safety, increase capacity and traffic flow, and increase aircraft efficiency. The Diverter program has been partitioned into five phases, the first three of which were performed under contract by Lockheed Aeronautical Systems Company, Marietta, GA. In the first two phases, which have been completed, the system requirements and desired functions were defined and a prototype decision-making aid was implemented and demonstrated on a workstation. In phase three, which is currently under way, the pilot/vehicle interface is being defined and the capability of the prototype is being improved. In the last two phases, which will be performed at NASA Langley Research Center, the interface will be implemented, tied into the prototype aiding software, and installed in an advanced simulation facility for testing. In addition, significant implementation issues may be addressed through flight testing on NASA research aircraft. Information is given in viewgraph form. Author

N91-10956*# Ohio State Univ., Columbus.

GRAPHICAL INTERFACES FOR COOPERATIVE PLANNING SYSTEMS

PHILIP J. SMITH, CHUCK LAYTON, and C. ELAINE MCCOY (San Jose State Univ., CA.) *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 219-228 Oct. 1990

Avail: NTIS HC/MF A12 CSCL 01/3

Based on a cognitive task analysis of 5 airline flight crews in a simulator study, researchers have designed a testbed for studying computer aids for en route flight path planning. This testbed runs on a Mac II controlling three color monitors, and is being used to study the design of aids for both dispatchers and flight crews. Specifically, the research focuses on design concepts for developing cooperative problem-solving systems. We use en route flight planning (selecting alternate routes or destinations due to unanticipated weather, traffic, malfunctions, etc.) as the context for studying the design of such systems. Researchers are currently exploring three questions in this test environment: (1) When interacting with a flight planning aid, how does the role of the pilot influence overall system performance; (2) Can the architecture for a cooperative planning system be built around Sacerdoti's (1983) concept of an abstraction hierarchy, where the pilot can interact with the system at many different levels of detail (but where the computer aid by default handles lower level details that the pilot has chosen not to deat with); and (3) Can graphical displays and direct manipulation of these displays provide perceptual enhancements (Larkin and Simon, 1987) of the pilot's problem-solving activities. Information is given in viewgraph form. Author

N91-10961*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

INFORMATION MANAGEMENT

WENDELL RICKS and KEVIN CORKER (BBN Systems and Technologies Corp., Cambridge, MA.) *In its* Aviation Safety/Automation Program Conference p 275-288 Oct. 1990

Avail: NTIS HC/MF A12 CSCL 01/3

Primary Flight Display (PFD) information management and

cockpit display of information management research is presented in viewgraph form. The information management problem in the cockpit, information management burdens, the key characteristics of an information manager, the interface management system handling the flow of information and the dialogs between the system and the pilot, and overall system architecture are covered.
Author

N91-10962*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A FLIGHT TEST FACILITY DESIGN FOR EXAMINING DIGITAL INFORMATION TRANSFER
CHARLES E. KNOX *In its* Aviation Safety/Automation Program Conference p 289-296 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Information is given in viewgraph form on a flight test facility design for examining digital information transfer. Information is given on aircraft/ground exchange, data link research activities, data link display format, a data link flight test, and the flight test setup.
Author

N91-10963# Allgemeiner Deutscher Automobil-Club-e.V., Munich (Germany, F.R.). Luftrettung.
AIR RESCUE IN THE FEDERAL REPUBLIC OF GERMANY [LUFFTRETTUNG IN DER BUNDESREPUBLIK DEUTSCHLAND]
INGO KARGER 1990 7 p In GERMAN
(ETN-90-97878) Avail: NTIS HC/MF A02

The air rescue system currently developed in the Federal Republic of Germany is such that any human being living there can be rescued within 8 to 15 minutes, using a rescue helicopter. The origin and operation of the rescue system are explained. The same rescue system is being developed in East Germany. ESA

N91-10964*# Atlantic Research Corp., Landover, MD. Professional Services Group.
CURRENT EMERGENCY LOCATOR TRANSMITTER (ELT) DEFICIENCIES AND POTENTIAL IMPROVEMENTS UTILIZING TSO-C91A ELTS Report, 1988-1990
BERNARD J. TRUDELL and RYLAND R. DREIBELBIS Oct. 1990 108 p
(Contract NASW-4228; NASW-4518)
(NASA-CR-4330; NAS 1.26:4330) Avail: NTIS HC/MF A06 CSCL 01/3

An analysis was conducted of current ELT problems and potential improvements that could be made by employing the TSO-C91a ELTs to replace the current TSO-C91 ELTs. The scope of the study included the following: (1) validate the problems; (2) determine specific failure causes; (3) determine false alarm causes; (4) estimate improvements from TSO-C91a; (5) estimate benefits from replacement of the current ELTs; and (6) determine need and benefits for improved ELT inspection and maintenance. A detailed comparison between the two requirements documents (TSO-C91 and -91a) was made to assess improved performance of the ELT in each category of failure cause and each cause of false alarms. The comparison and analysis resulted in projecting a success of operation rate approximately 3 times the current rate and a reduction in false alarms to 0.25 of those generated by TSO-C91 ELTs. These improvements led to a projection of benefits of approximately 25 additional lives to be saved each year with TSO-C91a ELTs and an improved inspection and maintenance program. Author

N91-10965# European Space Agency, Paris (France).
CONTRIBUTIONS TO THE IMPROVEMENT OF FLIGHT SAFETY IN WIND SHEAR
REINHARD KOENIG (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick, Germany, F.R.) Aug. 1990 193 p Transl. into ENGLISH of Beitraege zur Erhoehung der Flugsicherheit in Windscherungen (Brunswick, Fed. Republic of Germany, DFVLR), Dec. 1988 186 p Original language document was announced as N89-25144
(ESA-TT-1141; DFVLR-FB-88-49; ETN-90-98003) Avail: NTIS HC/MF A09

The problem of wind shear in aviation was addressed. On the basis of a suitable safety criterion which relates the aircraft's energy deviation to a permitted energy deviation level, uncontrolled, controlled and manual landing approach are analyzed. The wind disturbances employed are simplified simulations of horizontal wind shears, vertical winds and thunderstorm conditions. From the description of the repercussions of wind shear on the aircraft's energy budget, theoretical solutions for open/closed loop control producing increased flight safety are derived. Suitable measurement and filtering methods are selected. Advantages over conventional flight directors are exhibited by the concrete facilities for decreasing wind shear effects. The use of energy and performance error signals from instruments modified in relation to conventional specification give improvement in manual flight. Experimental investigations using a cockpit simulator prove that wind shear hazard can be reduced by suitable instrumentation. ESA

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

N91-10030 National Aerospace Lab., Tokyo (Japan).
THE ESTABLISHMENT AND PERFORMANCE TEST OF PAPI (PRECISION APPROACH PATH INDICATOR) SYSTEM FOR NAL STOL AIRCRAFT
YOSHITAKA MURAKAMI, YUSHI TERUI, TAKESHI HANAMATSU, KENJI SAITO, SHINTARO YOKOYAMA, and TOSHIHARU INAGAKI Jan. 1988 48 p In JAPANESE; ENGLISH summary
(NAL-TM-579; ISSN-0452-2982; JTN-90-80007) Avail: NTIS HC/MF A03

Flight tests of NAL QSTOL experimental aircraft are being conducted at Gifu airfield. The PAPI (Precision Approach Path Indicator) system was placed at the left side of runway 28 at Gifu airfield as a visual approach guidance aid both STOL and CTOL landings. This system is composed of eight-light units arranged in a line perpendicular to the runway. The beam angle of four units is set at six degrees for STOL approach and that of the other four units is set at three degrees for CTOL approach. The establishment and performance test results of the PAPI system are summarized. NASDA

N91-10031 National Aerospace Lab., Tokyo (Japan).
APPLICATION OF FLIGHT PATH RECONSTRUCTION ALGORITHMS FOR FLIGHT DATA OF HELICOPTER
SHUICHI SASAKI Mar. 1988 25 p In JAPANESE; ENGLISH summary
(NAL-TM-582; ISSN-0452-2982; JTN-90-80010) Avail: NTIS HC/MF A03

The maximum-likelihood algorithm, the Kalman filter, and smoother algorithms were applied to real flight data from a CH-47 helicopter (two flights) to estimate motion (attitude, position, and velocity) and sensor parameters (gains and biases of the rate gyros and accelerometers) of the craft. Performances of the algorithms were compared. Some attempts were also made to estimate sensor noise parameters. NASDA

N91-10032# Federal Aviation Administration, Washington, DC.
NATIONAL AIRSPACE SYSTEM: IN-FLIGHT ASSISTANCE OPERATIONAL CONCEPT
27 Jul. 1989 38 p
(PB90-233115; NAS-SR-1328) Avail: NTIS HC/MF A03 CSCL 17/7

This operational concept describes how in-flight assistance will be delivered in the National Airspace System (NAS). It is intended as a tool for systems designers, analysts, and operational test planners in determining if and how well the NAS design and its implementation meet the NAS requirements for in-flight assistance.

In addition, management and technical personnel of the FAA and other involved organizations are provided with a general description of how the In-flight Assistance service of the NAS operates. Author

N91-10033# Federal Aviation Administration, Atlantic City, NJ.
OPERATIONAL EVALUATION OF INITIAL DATA LINK AIR TRAFFIC CONTROL SERVICES. VOLUME 2: APPENDICES Final Report
NICHOLAS J. TALOTTA, CLARK SHINGLEDECKER, and MIKE REYNOLDS (Midwest Systems Research, Inc., Dayton, OH.) Feb. 1990 207 p
(DOT/FAA/CT-90/1-VOL-2) Avail: NTIS HC/MF A10

The results of an operational evaluation of Initial Data Link Air Traffic Control (ATC) Services are detailed. The Operational Evaluation was conducted at the Federal Aviation Administration (FAA) Technical Center utilizing the Data Link test bed. Initial Data Link services were evaluated in order to identify service delivery methods which optimize controller acceptance, performance, and workload. Author

N91-10034# Federal Aviation Administration, Atlantic City, NJ.
DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS) TEST PLAN Technical Report, Nov. 1989 - May 1990
L. FRANK PERSELLO Aug. 1990 16 p
(DOT/FAA/CT-TN90/15) Avail: NTIS HC/MF A03

The Federal Aviation Administration (FAA) Technical Center will conduct Differential Global Positioning System (GPS) tests to address the demands for high levels of accuracy in the terminal area. The tests employed a Convair 580 (CV-580) and two Motorola Eagle Mini Rangers. With the advent of the maturing GPS constellation, the FAA is assuming a more intensive stance in addressing the many questions/problems associated with GPS. These Differential GPS tests investigate the obtainable accuracy under static and dynamic conditions. The static tests will employ surveyed points as a base line. The dynamic tests will incorporate terminal area flightpaths and non-precision approaches using a laser tracker as a base line. The Differential tests will be conducted in an effort to build an FAA Differential GPS data base to aid in addressing GPS questions/problems. Author

N91-10957*# National Aeronautics and Space Administration. *Ames Research Center, Moffett Field, CA.*
ATC AUTOMATION CONCEPTS
HEINZ ERZBERGER *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 231-247 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Information on the design of human-centered tools for terminal area air traffic control (ATC) is given in viewgraph form. Information is given on payoffs and products, guidelines, ATC as a team process, automation tools for ATF, and the traffic management advisor. Author

N91-10958*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TIME-BASED OPERATIONS IN AN ADVANCED ATC ENVIRONMENT
STEVEN M. GREEN *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 249-260 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 17/7

Information on time-based operations in an advanced air traffic control (ATC) environment is given in viewgraph form. The objectives are to develop and evaluate procedures and clearances for 4D equipped aircraft, study the effect of dissimilar airborne and ground based speed strategies, and evaluate the effectiveness and acceptability of ATC automation tools. Information is given on ATC simulation, ATC automation tools, Denver arrival airspace, time-based ATC procedures, and future plans. Author

N91-10959*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TIME-BASED AIRCRAFT/ATC OPERATIONS STUDY
DAVID H. WILLIAMS *In its* Aviation Safety/Automation Program Conference p 261-269 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 17/7

Information on a time-based aircraft/air traffic control (ATC) operations study is given in viewgraph form. Study objectives are to develop and evaluate procedures for incorporating 4D-equiped aircraft into a 4D ATC system, determine the impact on the system of dissimilar airborne and ground 4D speed strategies, and evaluate the effectiveness of airborne time guidance. Information is given on future plans, separation conflict induced by dissimilar speed schedules, and airborne 4D procedures. Author

N91-10966# National Aerospace Lab., Tokyo (Japan). STOL *Aircraft Project Team.*
FLIGHT EVALUATION TEST OF THE PAPI (PRECISION APPROACH PATH INDICATOR) SYSTEM
KEIJI TANAKA, YUUSHI TERUI, and TOSHIHARU INAGAKI Jul. 1988 14 p In JAPANESE; ENGLISH summary
(NAL-TM-592; ISSN-0452-2982; JTN-90-80135) Avail: NTIS HC/MF A03

The National Aerospace Laboratory (NAL) quiet short takeoff and landing (QSTOL) experimental aircraft, ASUKA, is being tested at Gifu Airfield. Flight tests were conducted to evaluate the Precision Approach Path Indicator (PAPI) system, which Gifu Airfield recently installed. In order to support the ASUKA's flight test program, this PAPI has been designed to provide two reference approach path angles: three degrees (conventional takeoff and landing type) and six degrees (STOL type). The flight evaluation of the PAPI is evaluated here. The NAL experimental airplane, B65, in which a high-resolution type video tape recorder (VTR) camera was installed, was utilized to obtain images of PAPI lights. The tracing radar system on the ground recorded the traces of the B65 position. VTR images and radar data were then synchronized to confirm setting angles of PAPI lighting units, which can be estimated by the aircraft positions at the instant of color transition of each PAPI light. The results of the analysis as well as pilot comments, such as that PAPI has decreased pilot workload, proved the effectiveness and performance of the PAPI system. NASDA

N91-10967# *Advisory Group for Aerospace Research and* Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
AIRCRAFT TRAJECTORIES: COMPUTATION, PREDICTION, CONTROL, VOLUME 1. PART 1: FUNDAMENTALS. PART 2: FLIGHT IN CRITICAL ATMOSPHERIC CONDITIONS. PART 3: IMPACT OF NEW ON-BOARD TECHNOLOGIES ON AIRCRAFT OPERATION
ANDRE BENOIT, ed. Mar. 1990 267 p In ENGLISH and FRENCH
(AGARD-AG-301-VOL-1-PT-1-3; ISBN-92-835-0547-6; AD-A223568) Copyright Avail: NTIS HC/MF A12; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

This volume (part of a set of three) is composed of a preface and 11 papers covering respectively: fundamentals - general outline, optimal trajectories, and nonlinear models of aircraft; flight in critical atmospheric conditions - genesis of wind and influence on airplane trajectories, flight control in windshear, and flight simulation; and impact of new on-board technologies on aircraft operation - flight management in air transport, and crew/automation interface.

N91-10968*# Rice Univ., Houston, TX. Aero-Astronautics *Group.*
OPTIMAL TRAJECTORIES OF AIRCRAFT AND SPACECRAFT
A. MIELE *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 56 p Mar. 1990 Sponsored in part by Boeing Commercial Airplane Co.; Air Line Pilots Association, International; United States Aviation Underwriters; and Boeing Military Airplane Development

(Contract NAG1-516; JPL-956415)
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Work done on algorithms for the numerical solutions of optimal control problems and their application to the computation of optimal flight trajectories of aircraft and spacecraft is summarized. General considerations on calculus of variations, optimal control, numerical algorithms, and applications of these algorithms to real-world problems are presented. The sequential gradient-restoration algorithm (SGRA) is examined for the numerical solution of optimal control problems of the Bolza type. Both the primal formulation and the dual formulation are discussed. Aircraft trajectories, in particular, the application of the dual sequential gradient-restoration algorithm (DSGRA) to the determination of optimal flight trajectories in the presence of windshear are described. Both take-off trajectories and abort landing trajectories are discussed. Take-off trajectories are optimized by minimizing the peak deviation of the absolute path inclination from a reference value. Abort landing trajectories are optimized by minimizing the peak drop of altitude from a reference value. Abort landing trajectories are optimized by minimizing the peak drop of altitude from a reference value. The survival capability of an aircraft in a severe windshear is discussed, and the optimal trajectories are found to be superior to both constant pitch trajectories and maximum angle of attack trajectories. Spacecraft trajectories, in particular, the application of the primal sequential gradient-restoration algorithm (PSGRA) to the determination of optimal flight trajectories for aeroassisted orbital transfer are examined. Both the coplanar case and the noncoplanar case are discussed within the frame of three problems: minimization of the total characteristic velocity; minimization of the time integral of the square of the path inclination; and minimization of the peak heating rate. The solution of the second problem is called nearly-grazing solution, and its merits are pointed out as a useful engineering compromise between energy requirements and aerodynamics heating requirements. Author

N91-10978# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.

AIRCRAFT TRAJECTORIES: COMPUTATION, PREDICTION, CONTROL, VOLUME 3. PART 9: BOOK OF ABSTRACTS. PART 10: BIBLIOGRAPHY. PART 11: LIST OF CONTRIBUTORS

ANDRE BENOIT, ed. May 1990 155 p In ENGLISH and FRENCH
(AGARD-AG-301-VOL-3-PT-9-11; ISBN-92-835-0563-8; AD-A225266) Copyright Avail: NTIS HC/MF A08; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

This volume (part of a set of three) is composed of a short introduction, a Book of Abstracts of 39 papers included in the overall work, an extensive Bibliography which incorporate, in particular, most of the references cited by the 56 authors and co-authors, and a List of Contributors ordered by countries alphabetically. Both the Bibliography and the List of Contributors are each completed by an adequate index. Author

N91-10979# National Academy of Sciences - National Research Council, Washington, DC. Committee for the Study of Long-Term Airport Capacity Needs.

AIRPORT SYSTEM CAPACITY STRATEGIC CHOICES

1990 145 p
(SR-226; ISBN-0-309-04956-3; ISSN-0360-859X; LC-90-34787) Avail: NTIS HC/MF A07

The study reports on one element of overall future air transport systems needs: airport capacity. It was requested by the Federal Aviation Administration (FAA) to assist in a major undertaking by FAA and the U.S. Department of Transportation (DOT) that will lead to a national strategy for meeting long-term capacity needs. The Transportation Research Board (TRB) of the National Research Council assembled an expert committee to provide advice on alternative strategies that might be adopted to meet long-term airport capacity needs. The committee was charged with four tasks: (1) to examine long-term airport capacity needs and measures to meet these needs; (2) to formulate alternative strategies reflecting varying assumptions about the growth of air traffic and intercity travel demand, technological development, government roles, and institutional arrangements; (3) to identify the advantages and disadvantages of these strategies; and (4) to recommend strategies for further analysis and evaluation by FAA. The committee identified an array of actions or options that could be taken to meet demand. Seven strategies, made up of various combinations of these options, were devised and assessed under three growth scenarios. These scenarios, designated High Growth, Maturing Economy, and Economic Difficulty, embrace a range of plausible assumptions about the state of the economy, the cost of air travel, propensity for travel, and technological innovation in air and surface transportation. Each is described. The strategies are as follows: (1) continue on present course; (2) build more airports; (3) centralize system management; (4) build an expanded, centrally managed system; (5) let the market decide; (6) reconfigure the airport system; and (7) revolutionize the intercity transportation technology. The study evaluates the strategies suggested. Author

N91-10982# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

OPTIMUM ON-LINE HANDLING OF AIR TRAFFIC OVER WESTERN EUROPE

ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 6 p May 1990 Presented at the International Seminar ATC 2000, Luxembourg, 23-25 Feb. 1988
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For today's airlines, Western Europe is not very large and the flights they make within it do not last very long. Consequently it should be possible within such an area as Western Europe to arrange Air Traffic Control (ATC) clearances and instructions so that any flight will, from departure clearance to touch-down be conducted in accordance with airline policy and without the changes to route and profile due to short term planning which are so disruptive to air traffic. An approach is recommended for the on-line handling of air traffic over such an area, covering in particular the integration of control phases from departure to destination. This leads to a central on-line optimal definition of departure/arrival sequences and essential characteristics of all flights, and a series of regional units to implement the relevant proposals/directives. This should provide the optimum integration of adjacent Zones of Convergence in which the time and altitude at which aircraft enter and leave each Zone are precisely controlled and are affected by the traffic conditions in their corresponding space/time sphere of influence. As a prerequisite to the above, a system is proposed for the purpose of accurately predicting and controlling the 4-D trajectory of an aircraft over any part of a flight, and in particular that part which extends from entry into until exit from the airspace of a given control center. Author

N91-10983# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

THE EUROCONTROL FUTURE ATS SYSTEM CONCEPT AND THE PROGRAMME OF STUDIES, TESTS, AND TRIALS

V. VACHIERY *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 11 p May 1990
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The era of parallel, uncoordinated development of ground

systems and guidance, navigation and communications avionics is at an end. The pursuit of optimum economic operating conditions, coupled with the need to handle an increasing volume of traffic, demand that those responsible for Air Traffic Management apply solutions that easily combine available ground and air technologies. Cooperation between pilot and controller actions constitutes one of the keystones of the future systems. It is possible to increase the capacity and efficiency of air traffic management, while at the same time maintaining essential safety requirements, only by making more use of automation for control planning functions. It is considered that increased automation cannot provide real advantages, however, unless the accuracy of aircraft trajectory prediction is greatly improved. This was made clear in the description of the Future ATS Concept drawn up by EUROCONTROL. The Concept is presented in broad outline. Its implementation will call for a number of studies and trials, and a rundown is given of EUROCONTROL's program. The program places great emphasis on analysis of the conditions that need to be met to enable ground systems in future to have available facilities for the acquisition and exploitation of aircraft state vector parameters. The key aspects of the program are: (1) Improvement of the surveillance system; (2) Improvement of Air/Ground communications (Automatic data link); (3) Increased automation; and (4) Improvement of evaluation methods by using a realistic representation of the airborne side. Author

N91-10988# Consiglio Nazionale delle Ricerche, Rome (Italy). Progetto Finalizzato Trasporti and Ist. di Analisi dei Sistemi ed Informatica.

OPTIMIZATION MODELS AND TECHNIQUES TO IMPROVE AIR TRAFFIC MANAGEMENT

LUCIO BIANCO *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 22 p May 1990

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A survey of earlier works is given with particular emphasis on optimization models and solution techniques. First, a multilevel model of the different ATC functions is proposed. Then, attention is devoted to the on-line control functions (flow control, on-line strategic control of flights and aircraft sequencing in the terminal area); for each problem, an optimization model is established and a solution technique is illustrated. The numerical behavior is also discussed. Author

N91-10989# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

THE HIGH-RESOLUTION GRAPHIC DISPLAY: A POSSIBLE MAN/MACHINE INTERFACE FOR A COMPUTER ASSISTED ATC MANAGEMENT SYSTEM

CARLOS GARCIA AVELLO *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 6 p May 1990

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An application is described of high resolution graphic display in the field of management and control of air traffic in an extended area including a major terminal, the radius of the area being liable to vary from 150 to 300 nm. Reference is made to air traffic management and 4-D guidance techniques for individual aircraft in a Zone of Convergence (ZOC) in the knowledge that the graphic display techniques are applicable virtually to all systems affording the controller assistance at the decision making level. For the purpose of presenting data to the controller, a graphic rectangular display is employed having a resolution of 1280 by 1024 points, capable of displaying 16 colors. A circular display similar to most existing radar scopes could of course be used if it had equivalent resolution and color characteristics. The management directives and orders for guidance are presented to the operator, area manager or controller of an individual sector as part of the set of data displayed on the radar surveillance and control scope without the use of additional special tabular displays. Author

N91-10990# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

THE 4-D CONTROL OF CURRENT AIR CARRIERS IN THE PRESENT ENVIRONMENT: OBJECTIVES, STATUS, AND PLANS

ANDRE BENOIT *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 7 p May 1990

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The accurate control of the time of arrival of aircraft will play an essential role in the efficient conduct of air traffic in terms of both economy and capacity. A technique was developed to select efficiently and control accurately each aircraft trajectory inbound to medium to high density traffic airports. The selection is made in terms of the overall traffic on the basis of the airline or pilot-preferred criterion, either cost, consumption or time, and the subsequent control is made in a ground/air co-operative manner, using whenever applicable speed and/or track corrections. The 4-D control is studied along with individual trajectories as applicable to current air carriers in the present environment directly adaptable to future automated air/ground digital communications. The overall control loop was simulated in an environment representing in particular the Belgian airspace configuration, using various flight simulators in conjunction with airline pilots and air traffic controllers. The results obtained to date make it possible to envisage on-line tests in the near future, aiming at a 10-second accuracy at the runway threshold for current commercial aircraft. Author

N91-10991# Centre d'Etudes et de Recherches, Toulouse (France).

FOUR DIMENSIONAL NAVIGATION IN AIR TRAFFIC WITH 4-D NAVIGATION AIRCRAFT [NAVIGATION 4-D EN CIRCULATION AERIENNE AIRCRAFT 4-D NAVIGATION]

NICOLE IMBERT and MARC J. PELEGRIN *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 16 p May 1990 In FRENCH; ENGLISH summary

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Bearing in mind that the waiting times before landing are always increasing while the maximum landing rates are not reached, the monitoring of one more parameter during the approach is suggested. This is, in fact, two speed corrections and one heading correction (Nav. 4D, 3 space dimension + time). The first problem to be solved is the choice of the mathematical model to be used to simulate a plane. A model as complete as possible (in fact of the 18th order) was the starting point and it was degraded until a criterion was no longer satisfied. This criterion was a measurement of the error between the complete model and the degraded model along a reference trajectory (Roissy approach) of 54 km extension. It was assumed that the error due to the use of a simpler model should not reach + or - 320 m at the ILS entry beacon. A 6th order model was declared acceptable. After a number of simulations it was shown that corrections must arise after the entrance in the zone of convergence (ZOC) during the flight at constant level (speed correction) in the middle of the descent flown at constant indicated speed, (speed correction) and during the last leg before

the ILS capture (heading correction). By a management method using a mathematical model on a fast time basis, an optimal time of arrival at the ILS entrance beacon can be determined, corresponding to an easy to fly trajectory. A model of the atmosphere must be used and it was checked that the robustness of the method (3 corrections) with regard to this model is correct. It was also checked that the time when the final beacon is reached is not sensitive to the mass of the plane at the entrance point.
Author

N91-10992# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
THE CONTROL OF INBOUND FLIGHTS
ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 10 p May 1990
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The basic principles are described of the method to guide aircraft accurately down to the runway in a time-of-arrival constrained environment. The method is designed to be used in a Zone of Convergence context or in any similar advanced Air Traffic Control (ATC) system characterized by the integration of control phases over an extended area on the one hand and true computer assistance to the air traffic controller on the other, i.e., assistance provided at the decision making level through the automatic generation of guidance advisories. The method includes two closely coupled basic components, namely, a predictor, which computes a trajectory once initial conditions and plans are known, and a profile manager, which adapts the plans to meet the time constraint and generates the guidance directives on the basis of present position, actual surveillance information, aircraft operation and route constraints.
Author

N91-10993*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
GUIDANCE CONCEPTS FOR TIME-BASED FLIGHT OPERATIONS
DAN D. VICROY *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 12 p May 1990
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Airport congestion and the associated delays are severe in today's airspace system and are expected to increase. NASA and the FAA is investigating various methods of alleviating this problem through new technology and operational procedures. One concept for improving airspace productivity is time-based control of aircraft. Research to date has focused primarily on the development of time-based flight management systems and Air Traffic Control operational procedures. Flight operations may, however, require special onboard guidance in order to satisfy the Air Traffic Control imposed time constraints. The results are presented of a simulation study aimed at evaluating several time-based guidance concepts in terms of tracking performance, pilot workload, and subjective preference. The guidance concepts tested varied in complexity from simple digital time-error feedback to an advanced time-referenced-energy guidance scheme.
Author

N91-10994*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 4-D DESCENT TRAJECTORY GENERATION TECHNIQUES UNDER REALISTIC OPERATING CONDITIONS
DAVID H. WILLIAMS and CHARLES E. KNOX *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 22 p May 1990
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NASA-Langley has been conducting and sponsoring research in airborne energy management for a number of years. During the course of this research, two fundamental techniques for the generation of 4D (fixed time) descent trajectories have emerged as viable candidates for advanced flight management systems. The first technique utilizes speed schedules of constant Mach number transitioning to constant calibrated airspeed chosen empirically to produce minimum fuel usage. The second technique computes cost optimized speed schedules of variable airspeed developed through application of optimal control theory. Both techniques have been found to produce reasonable and flyable descent trajectories. The formulation of the algorithms for each technique is evaluated and their suitability for operations in realistic conditions is discussed. Operational factors considered include: airplace speed, thrust, and altitude rate constaints; wind, temperature, and pressure variations; Air Traffic Control altitude, speed, and time constaints; and pilot interface and guidance considerations. Time flexibility, fuel usage, and airborne computational requirements were the primary performance measures.
Author

N91-10995# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
EXPERT SYSTEMS FOR THE GENERATION OF THERMAL AREA ARRIVAL PATHS FOR CIVIL TRANSPORT
ROBERT W. SIMPSON *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 14 p May 1990
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Efficiencies can be gained from dynamic scheduling of the takeoff and landing operations for the system of runways at a major civil airport. It is then necessary to be able to generate a conflict-free set of flight paths which implements this schedule, and which can be easily changed. For landing arrival aircraft, these flight paths start at a known time, point and speed in the descent towards the airport, and end at a reduced speed and time at the outer marker of the final approach to the assigned runway where desired in-trail separations must be achieved. To generate sets of conflict-free arrival paths, an expert systems computer program finds and selects a path feasible within the performance limits of each aircraft from a set of patterns which are easily understandable by the human controller. This technique is easily adaptable to the geometric characteristics of different terminal areas and runway configurations, and easily accepts rules and procedural limitations which can be specified and implemented by ATC controllers themselves, as desired.
Author

N91-10996*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A DESCRIPTION AND EVALUATION OF TIMER: A TIME-BASED TERMINAL FLOW-CONTROL CONCEPT
LEONARD CREDEUR and WILLIAM R. CAPRON (PRC Kentron, Inc., Hampton, VA.) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 42 p May 1990

 CSCL 17/7

A description of a time-based ATC concept called TIMER (Traffic Intelligence for the Management of Efficient Runway-scheduling) and the results of a fast time and real time computer evaluation are presented. The concept was designed to improve the efficiency of extended terminal area operations (en route approach, transition, and terminal flight to the runway). TIMER integrates en route metering, fuel efficient cruise and profile descents, terminal sequencing and spacing together with computer-generated controller aids, in order to fully use runway capacity and improve efficiency of delay absorption. The concept, by using simplified aircraft models, accommodates both 4-D and non 4-D equipped aircraft and is designed for integration into the manual; voice linked ATC system in an evolutionary manner and still be able to accommodate proposed system upgrade features such as data link and further ground automation. Fast time and real time computer simulation results identify and show the effects and interactions of such key variables as horizon of control, metering fix and final approach delivery time errors, aircraft separation requirements, delay discounting, wind, flight technical error, and knowledge of aircraft final approach speed. The current ATC system has a runway interarrival-error standard deviation of approx. 26 seconds. Simulation results indicate that, with computer aiding, the runway interarrival-error standard deviation for non 4-D equipped traffic can be reduced to the region of 8 to 12 seconds if expected final approach speed is known; however, the reduction is only in the region of 16 to 20 seconds if expected final approach speed is unknown. Another major finding is that en route metering fix delivery-error standard deviation should be kept to less than a number somewhere between 35 to 45 seconds to achieve full runway capacity. This requirement implies the need for either airborne automation or assistance to the controller since the current manual performance in today's en route metering environment is in the order of 1.5 minutes. Author

N91-10997# Boeing Commercial Airplane Co., Seattle, WA.
USE OF 4-D RNAV IN TIME-BASED EN ROUTE ARRIVAL METERING

R. L. ERWIN and K. H. IZUMI *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 19 p May 1990

Arrival metering in en route airspace can match the demand rate to the airport acceptance rate. Air traffic control (ATC) is evolving time-based control techniques to facilitate en route arrival metering. This allows fuel savings by using speed reduction to absorb delay. The logic for en route arrival metering: (1) estimates the undelayed landing time of each arrival; (2) assigns the earliest available landing time; and (3) controls each arrival to its terminal area arrival (feeder) fix according to the common schedule developed for all arrivals. The airplane flight management system (FMS), used along with the ATC computer as part of a distributed data processing system, can define a minimum fuel cruise and descent flight profile which is consistent with ATC constraints. A study of four-dimensional area navigation (4D RNAV) operational requirements for use in en route arrival metering has determined the functions and time-guidance accuracies needed for ATC compatible operations. A 4D RNAV capability is most easily achieved by wrapping a time navigation capability around a 3D FMS. Concepts for controlling a mix of 4D RNAV equipped and unequipped aircraft in a time-based en route arrival metering system have been the subject of on-going analyses and simulations by NASA-Ames. The use of 4D RNAV in en route arrival metering operations can save the operator fuel, reduce both pilot and controller workload, and reduce terminal airspace congestion. Author

N91-10998# European Organization for the Safety of Air Navigation, Brussells (Belgium). Enguneering Directorate.
AIR TRAFFIC MANAGEMENT AND AIRCRAFT GUIDANCE IN A ZONE OF CONVERGENCE

ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 4 p May 1990

The basic principles of air traffic management and guidance of individual aircraft in a Zone of Convergence (ZOC) have been presented in previous papers at successive stages in the development of the project. These principles are summarized as is their applicability to the actual operational environment, compatibility with present technology and direct adaptability to future developments, the quality of the interfaces involving the air traffic controller and the aircraft crew and the resultant benefits to the community in terms of economy, use of available capacity and safety. Author

N91-10999# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
GROUND-BASED 4-D GUIDANCE OF FLIGHTS IN STRONG WIND

ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 13 p May 1990

In strong wind, groundspeed may vary appreciably during a turn, just as for example in the case of a landing after a U-turn preceding the localizer intercept. Such conditions are critical for maximum use of the runway, and render human estimation of aircraft motion extremely difficult. The tests are summarized which were conducted using a ground-based 4D guidance program, developed to assist the air traffic controller in maintaining the predicted landing time sequence with an accuracy better than 10 seconds for each arrival. Author

N91-11000*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A PILOTED SIMULATOR EVALUATION OF A GROUND-BASED 4-D DESCENT ADVISOR ALGORITHM

THOMAS J. DAVIS, STEVEN M. GREEN, and HEINZ ERZBERGER *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 10 p May 1990 Previously announced in IAA as A87-50525

 CSCL 17/7

A ground-based, four dimensional (4D) descent-advisor algorithm is under development at NASA-Ames. The algorithm combines detailed aerodynamic, propulsive, and atmospheric models with an efficient numerical integration scheme to generate 4D descent advisories. The ability is investigated of the 4D descent advisor algorithm to provide adequate control of arrival time for aircraft not equipped with on-board 4D guidance systems. A piloted simulation was conducted to determine the precision with which the descent advisor could predict the 4D trajectories of typical straight-in descents flown by airline pilots under different wind conditions. The effects of errors in the estimation of wind and

initial aircraft weight were also studied. A description of the descent advisor as well as the result of the simulation studies are presented. Author

N91-11001# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
THE AIR TRAFFIC CONTROLLER FACING AUTOMATION: CONFLICT OR COOPERATION
ANDRE BENOIT, SIP SWIERSTRA, and RENE DEWISPELAERE (Eurocontrol Agency, Brussels, Belgium) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 7 p May 1990 Presented at the International Conference NAV 1987, London, England, 29 Sep. - 1 Oct. 1987

Today, developments in ground-based and on-board computers, navigation and digital air/ground/air communications make it possible to envision, for tomorrow, extensive automation of the overall air traffic control process, always provided that reliability, safety and responsibilities can be absolutely covered in all possible eventualities, however remote. Accordingly, before tomorrow, an appreciable amount of traffic will cross our skies and be handled by air traffic controllers without the support of advanced automated tools. Nevertheless, at the same time, the potential of automation will continue to increase. This subject is discussed in the light of the experience gained during the development of an approach to the definition, assessment and testing in an operational environment of a procedure suitable for guiding aircraft along 4-D trajectories illustrative of the next system generation of ATC. The essential aspects are examined of the computer/controller/pilot/aircraft chain of dialogues, placing the emphasis on the interface between the computer and the controller, the intelligent interpretation of the surveillance information by the computer, the definition, generation, and relay of guidance directives to the pilot and finally, the use of navigation aids. The integration of the ground-based 4-D guidance and control system messages on a standard ATC radar display is shown, illustrating this for the guidance of flights conducted by SABENA crews operating B-737 and DC-10 aircraft. Author

N91-11002# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
AIRCRAFT TRAJECTORY RECONSTITUTION ON THE BASIS OF MULTI-RADAR PLOT INFORMATION
P. VANDERKRAAN *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 2 p May 1990

A short description of the various techniques in use for the establishment of aircraft reference trajectories is presented. Then a description of the principles and operation of the EUROCONTROL program MURATREC (Multi-Radar Trajectory Reconstitution) follows, covering in particular: (1) estimation of systematic radar errors; (2) curve fitting by the use of B-splines and dynamically adaptable spline steps; (3) accuracy of the reconstructed positional information; and (4) reconstitution of altitude, accelerations and speed. Applications of the MURATREC program are outlined, including application for the analysis of radar plot and track accuracy (examples) and possible applications for incident investigations, on-line alignment of multi-radar information and simulation of aircraft trajectories in a given radar environment. Author

N91-11003# National Aerospace Lab., Amsterdam (Netherlands).
BAYESIAN MULTI-SENSOR TRACKING FOR ADVANCED AIR TRAFFIC CONTROL SYSTEMS
H. A. P. BLOM, R. A. HOGENDOORN, and F. J. VANSCHAIK *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 8 p May 1990 Sponsored by Dutch Civil Aviation Board

An overview is given of a Bayesian tracking system for a multi-sensor environment. The main modules perform track initiation, track continuation and systematic error estimation, respectively. The track continuation module plays for Air Traffic Control the most important role. It consists of a combination of those approximate Bayesian methods that proved to be the most efficient for the main problems of track continuation: Extended-Kalman filtering for nonlinear dynamics, Probabilistic Data Association for unassociated measurements and Interacting-Multiple-Model filtering for sudden maneuvers. Comparisons of this new tracking system with alpha-beta Kalman based and state-of-the-art tracking systems show its superiority for application to Air Traffic Control surveillance. It provides better track continuity, more accurate expectations of position and velocity and more complete additional information in the form of probabilities of modes of flight (turning, accelerating and straight modes) and consistent estimates of its own accuracy. With this track information, advanced Air Traffic Control systems may better cope with the many uncertainties that are inherent to air traffic. Author

N91-11004# Technical Univ. of Crete, Athens (Greece).
THE USE OF DOWNLINKED MEASUREMENTS TO TRACK CIVIL AIRCRAFT
C. C. LEFAS *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 21 p May 1990

The use is described of measurements made on board civil aircraft to improve tracking accuracy in air traffic control (ATC) systems. The measurements are transmitted to the ground station via the Secondary Surveillance Radar (SSR) mode S data link. First the widely used alpha-beta filter and the first order Kalman filter are reviewed. Next the problem of maneuver handling is described and it is established that significant improvements, in terms of tracking accuracy, are expected when tracking maneuvering aircraft. The shape of maneuvers is examined using recordings made on board civil aircraft during normal scheduled services. The on-board measurements considered are roll angle, heading, and true air speed (TAS). Roll angle and the rate of change of heading are theoretically equivalent, since they are related though aircraft velocity. Maneuver tracking filters using either roll angle or heading are described and compared. It is shown that the filter using heading provides a better performance in the event of missing replies, since changes of heading are eventually detected. Both filters cannot track longitudinally accelerating targets. Next the use of velocity measurements, derived from TAS and heading, is considered. A filter is described that is capable of estimating the wind speed in the vicinity of the aircraft. The same filter provides satisfactory tracking accuracy during maneuvers and can handle longitudinal accelerations. Under monoradar coverage, where the data rate and accuracy are fairly constant, the filters reduce to a particularly simple form, that may

be regarded as an enhanced alpha-beta filter. The performance of the filters is evaluated using data recorded during normal scheduled services. Author

N91-11005# Service Technique de la Navigation Aerienne, Paris (France). Dept. Radiocommunication et Radioguidage.
CONTRIBUTION OF THE SATELLITE TECHNIQUES TO THE SURVEILLANCE OF AIR TRAFFIC [L'APPORT DES TECHNIQUES SATELLITAIRES A LA SURVEILLANCE DE LA NAVIGATION AERIENNE]
OLIVIER CAREL *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 13 p May 1990 In FRENCH; ENGLISH summary
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The International Civil Aviation Organization asked a special committee FANS (Future Air Navigation Systems) to study satellite system implementation for communication navigation and surveillance applications. This committee recently issued its final report. FANS work is presented and the consequences are analyzed of satellite system implementation in case of the surveillance of air traffic. The most important element will be Automatic Dependent Surveillance (ADS) which implies the automatic air to ground return transmission of various airborne measured parameters, i.e., mainly aircraft position as supplied by the aircraft navigation equipments. This concept allows a much more efficient air traffic control in every area lacking a ground infrastructure. In continents areas with heavy air traffic, satellites will not substitute the secondary surveillance radar. The new techniques however will allow a flexible design of the ground infrastructure. Author

N91-11007# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
INTEGRATION OF AIRCRAFT CAPABILITY IN AIR TRAFFIC HANDLING SIMULATIONS
ANDRE BENOIT, SIP SWIERSTRA, and YVES DELNATTE (Belgian World Airlines, Brussels.) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 7 p May 1990
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The incorporation of airline/aircrew/aircraft specific procedures and performances into simulations and air traffic handling operations is a prerequisite for the next generation of management and control techniques. This matter is analyzed in the light of the shortcomings inherent in the present situation, in order to meet operators' demands in terms of capacity and efficiency. A practical approach is then proposed which includes the operators (aircrew/aircraft/avionics) in the overall ground/air/ground control loop at development, assessment, validation, and real time simulation levels. As an illustration of the potential offered, this approach is used to assess a ground/air coordinated 4-D guidance technique, and the results are summarized. Author

N91-11008# Technische Univ., Brunswick (Germany, F.R.). Inst. of Aeronautics and Astronautics.
SIMULATION OF AUTOMATED APPROACH PROCEDURES CONSIDERING DYNAMIC FLIGHT OPERATIONS
MANFRED FRICKE and ANDREAS HOERMANN *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 16 p May 1990
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During peak hours almost all major commercial airports operate close to their capacity limits. Moreover, the traffic demand often exceeds the offered capacities leading to more or less stringent restrictions in slot allocation. The purpose of the fast-time air traffic simulations, was to analyze and assess the performance and the practicability of automated time-based approach concepts, currently developed to optimize the terminal area air traffic process with respect to safety, capacity and economy. The developed program system TASIMD (Terminal Area SIMulation considering the aircraft Dynamics) simulates flight operations of arriving aircraft within a terminal area during a specific time interval. TASIMD models all major elements of a TMA scenario related to the control and operations of automated approach procedures on the ground and in the air (e.g., surveillance, control procedures, aircraft dynamics, flight guidance). The aircraft fly along 4D-trajectories, described by a horizontal profile, an altitude profile and a speed profile to integrate the time element, considering influences on the path following accuracy in space and time. Sources of error impact are: entry fix time deviation, navigation, wind, airspeed error and profile management algorithm error. Errors are modeled in Monte-Carlo technique. Two types of automated approach procedures were developed and analyzed: a variable path speed control concept (VPSC) and a fixed path speed control concept (FPSC). Both concepts presume a shared air/ground responsibility for profile control. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A91-10341# Toledo Univ., OH.
THERMAL ANALYSIS OF ENGINE INLET ANTI-ICING SYSTEMS
THEO G. KEITH, JR., KENNETH J. DEWITT (Toledo, University, OH), JAMES K. NATHMAN (Analytical Methods, Inc., Redmond, WA), DONALD A. DIETRICH (General Electric Co., Cincinnati, OH), and KAMEL M. AL-KHALIL Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 628-634. Research supported by General Electric Co. and NASA. Previously cited in issue 09, p. 1291, Accession no. A89-25565. refs
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A91-10956
CONCORDE - 1958-1975
G. CORMERY IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 58-65.
Copyright

An overview of Concorde research, design, and development evolution is presented. The various airframe geometries considered for attaining a Mach 2.2 max cruise limit imposed by various temperature limitations are described. Final selection of a delta wing plus a foreplane resulted after a number of wing, fuselage and empennage combinations were evaluated. Other areas requiring advanced research and design that had to be solved included: jet engine type selection, number and positioning, visibility problems in landing and takeoff attitudes that led to adoption of the droop nose, systems integration with particular regard to flight controls and the automatic flight control system, and the evolution of the air intake system to accommodate operation over the entire flight envelope. Finally, a general assessment of Concorde commercial operation is presented. R.E.P.

A91-10957
COMMERCIAL SUPERSONIC OPERATIONS - THIRTEEN YEARS OF EXPERIENCE WITH CONCORDE
S. J. SWADLING (British Aerospace/Commercial Aircraft/, Ltd., Filton, England) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 66-71.

This paper is intended to give a brief overview of Concorde in-service operations as viewed by the manufacturer. It identifies the features peculiar to Concorde as a supersonic transport and problems and major incidents encountered during development flying and operation. Finally it covers in-service experience and identifies the most troublesome items. Author

A91-10967
SST AIRFRAME INTEGRATION FOR A MACH 2 TRANSPORT
D. COLLARD (*Aerospatiale, Division Avions, Paris, France*) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 188-198.

The development of Aerospatiale's ATSF future supersonic transport is presented. Initial design methods call for a Mach 2 cruise level to permit constant verification between actual flight experience and new design concepts. Details of aerodynamics, structural design , materials available, and powerplant installation are discussed. Configuration development, cruise lift/drag improvement, structural layout, and cockpit design modifications are described. Engine selection considerations involving candidate engine cycles, engine installation and intake development are also described. The improvements being made in low speed performance and engine noise emission appear likely to achieve today's noise criteria by 2005. R.E.P.

A91-11715
HARRIER - THE NEXT 30 YEARS
SIMON ELLIOT Flight International (ISSN 0015-3710), vol. 138, Sept. 18, 1990, p. 50-54, 56, 57.

A review of the Harrier aircraft history from the first vectored-thrust V/STOL flight to today's advanced versions is presented. The growth and lifting capacity of the aircraft is shown to be in great part due to the vectored-thrust engine that has more than doubled in thrust in the thirty years since its first flight. Current Harriers in their various land/sea versions have become full-fledged combat aircraft capable of carrying military weaponry loads that once required long runways just to get off the ground. Sea Harriers are presently operational aboard aircraft carriers of the U.S., Britain, Spain, and India, and the AV-8B night-attack version of the USMC has been operating since 1989. Some aspects of a study for a supersonic advanced short-takeoff/vertical landing aircraft for service early next century are discussed. R.E.P.

A91-11723#
HELICOPTER GROUND RESONANCE [REZONANS NAZIEMNY SMIGLOWCA]
JERZY BOJANOWSKI (Warszawa, Politechnika, Warsaw, Poland) Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 119, 1989, p. 3-47. In Polish. refs
The description of a helicopter ground resonance given here contains relatively full set of relevant specific topics. For brevity, the description is constrained to a model of a rotor with n not less than 3 rigid blades fixed elasticly to the rotor hub. Simplified model of the tensor rigidity of an undercarriage, useful mainly to ski landing gear, is assumed. Evaluation of motion equations of a single blade is given. Their linearization and superposition lead to the motion equations of the whole rotor in the scope which is needed to complete all motion equations used in resonance description. Also, the motion equations of a fuselage connected to a ski landing gear situated on the ground is presented. Exact solutions of the set of differential motion equations are given together with their description in regard with undamped and artificially damped system. In both cases, stability criteria are discussed with special regard to simplified calculation methods. Mass center motion of the revolving rotor is considered using the double complex numbers calculations. Author

A91-11724#
SIMULATION INVESTIGATIONS OF THE HELICOPTER GROUND RESONANCE [BADANIA SYMULACYJNE REZONANSU NAZIEMNEGO]
MAREK SZRAJER Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 119, 1989, p. 48-67. In Polish.
On the basis of a relatively simply numerical model of the helicopter resonance, a possibility of computer simulation methods for the solution of complex relevant problems is shown. Sample simulation calculations made on an IBM PC microcomputer using the program given by Szrajer (1989) are presented. In the simulation, a possibility of defects and nonlinearity of some helicopter construction elements are considered. It is also possible to simulate a pilot reaction to a dangerous helicopter vibration amplitude increase. Graphical presentation of the results simplifies analysis. To check the assumed model of the resonance, the results from Zerek (1984), based on analytical calculations and accepted in practice, were used. The results indicate that the method can be used for more complex models of the helicopter ground resonance. Author

A91-11725#
THE GROUND RESONANCE OF A HELICOPTER WITH A ROTOR OF IDEAL AND APPROXIMATE SYMMETRY CONSIDERING THE ROTOR-BLADE VIBRATION IN THE THRUST PLANE [REZONANS NAZIEMNY SMIGLOWCA Z WIRNIKIEM O DOSKONALEJ I PRZYBLIZONEJ SYMETRII Z UWZGLEDNIENIEM DRGAN LOPAT W PLASZCZYZNIE CIAGU]
LUDWIK ZEREK Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 119, 1989, p. 68-98. In Polish. refs
Basic theoretical problems of the helicopter ground resonance with one rotor of an ideal and approximate axis symmetry is discussed. The vibrations of rotor blades in the thrust plane are considered. Physical and mathematical models of a helicopter and external influences are shown. Methods of the motion equations statement and of their stability investigation are given. Classification of special cases important in practice is presented. Author

A91-11863#
X-31 WILL TURN ON A DIME
RICHARD DEMEIS Aerospace America (ISSN 0740-722X), vol. 28, Oct. 1990, p. 26-29.

The current status of the X-31 project is reviewed with particular reference to the aims of the project, history of development, and general design concept. The X-31, an Enhanced Fighter Maneuverability aircraft, will operate in the low supersonic region (maximum speed Mach 1.3) and engage in aerial combat at angles of attack approaching 70 deg. Wind tunnel test results are examined, and the future of the project is briefly discussed. V.L.

A91-12062
THE ATF BATTLE SHAPES UP
BILL SWEETMAN Interavia Aerospace Review (ISSN 0020-6512), vol. 45, Oct. 1990, p. 862-865.

Basic data for the YF-22/-23 prototypes that will compete in the Advanced Tactical Fighter competition are presented. Though both aircraft will be using the same engines and other similarities exist such as avionics systems designed to use the same architecture, the two are radically different. The YF-22 has a single body structure beneath a shoulder-mounted wing, engines set close together, two large canted vertical tails and separate horizontal stabilizers. The wing planform is described as a trapezoid/clipped delta with some forward sweep on the trailing edge. The YF-23 is considerably longer with the engine nacelles and forward fuselage

blended together in the center of a midset wing having a diamond shape planform with equal sweep back on the leading and trailing edges. A pair of V-tails provides pitch and yaw control, and four large trailing edge surfaces act as flaperons and speedbrakes. Stealth features are given high priority in both aircraft as specified by the USAF. Possibly the most significant difference in the two designs is the incorporation of thrust vectoring in the YF-22. This paper also provides some description of weapons systems and bays. R.E.P.

A91-12063
A SUPERLATIVE FROM SUKHOI - THE SU-27
ROY BRAYBROOK Air International (ISSN 0306-5634), vol. 39, Oct. 1990, p. 203-208.
Copyright

A background review of the Sukhoi design bureau is first presented along with the progressive aircraft types that have led to the present SU-27 fighter-interceptor. The original design of this aircraft had a fixed wing of moderate sweep, and the fuselage was raised above the wing to leave a channel between the engines in which two large air-to-air missiles could be mounted in tandem. A comparison with the F-14/15 fighters appears to place them on a roughly equal performance footing. However, the SU-27 has the added advantage of the agility and lift/drag ratio benefits of a FBW system and longitudinal instability. Some additional information is given in regard to weaponry and avionics as well as a detailed cutaway diagram. R.E.P.

A91-12165
EXTENSIVE MD-11 AUTOMATION ASSISTS PILOTS, CUTS WORKLOAD
DAVID HUGHES Aviation Week and Space Technology (ISSN 0005-2175), vol. 133, Oct. 22, 1990, p. 34-41, 45.
Copyright

The automated flight management system incorporated in the MD-11 aircraft includes such advanced features as automatic augmentation in pitch, roll and yaw. An autothrottle portion of the automatic flight system keeps the pilot from unintentionally flying too fast or too slow in a given configuration. The system also provides automatic navigation in both lateral and vertical dimensions and will control optimum speeds and altitudes, including step climbs to cruise altitude, to achieve the most efficient fuel consumption on a particular route. In the cockpit, a dynamic fuel system diagram is displayed that tracks fuel levels in the various tanks and notes with changing colors when fuel pumps are on or off. Any portion of the automated system can be converted to manual operation as desired. The systems display features a cathode ray tube that presents all of the data necessary for an ICAO position report, plus additional useful information. This paper also provides a technical table of MD-11 aircraft and engine details. R.E.P.

A91-12224#
MOTION ANALYSIS OF RPRVS USING ON-BOARD AND GROUND-BASED MEASUREMENTS
AKIRA SAKURAI and SHUICHI NAKAYAMA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 63, Aug. 1990, p. 343-349. In Japanese, with abstract in English. refs

A low-cost flight test system using RPRVs (Remotely-Piloted Research Vehicles) is under development. In this system, the acceleration and angular velocity of aircraft are detected with on-board acceleration and angular rate sensors with a high sampling rate, while the flight path and attitude are photographically determined using a pair of optical trackers with a much lower sampling rate. A method of combining these two types of data has been developed, in which the initial values and several other sensor-related parameters necessary for the integration of the acceleration and angular velocity are determined in such a way that the calculated flight path and attitude of the aircraft show best least-square fit with the tracker results. Author

A91-12894*# California Univ., Los Angeles.
INFLUENCE OF UNSTEADY AERODYNAMICS ON ROTOR BLADE AEROELASTIC STABILITY AND RESPONSE
P. P. FRIEDMANN (California, University, Los Angeles) and L. H. ROBINSON (McDonnell Douglas Helicopter Co., Mesa, AZ) (International Conference on Rotorcraft Basic Research, 2nd, College Park, MD, Feb. 16-18, 1988, Proceedings) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1806-1812. Previously cited in issue 22, p. 3645, Accession no. A88-51765. refs
(Contract NAG2-209; NAG2-477)
Copyright

A91-12919
DIAGNOSTICS OF AVIATION ELECTRIC MACHINES [DIAGNOSTIROVANIE AVIATSIONNYKH ELEKTRICHESKIKH MASHIN]
VLADIMIR N. POTAPOV Moscow, Izdatel'stvo Transport, 1989, 104 p. In Russian. refs
Copyright

The operating conditions of electric machines used in aviation are analyzed, as are the major causes of failures, physical processes associated with the occurrence of defects, and characteristic symptoms preceding failures. A method is proposed for the experimental evaluation of the parameters of diagnostic models. Structural schemes are presented which illustrate the principles of implementation of diagnostic methods. Various aspects of the automation of diagnostic procedures using computerized measurement and signal processing systems are discussed. V.L.

N91-10038 National Aerospace Lab., Tokyo (Japan). STOL Aircraft Project Group.
THE ACTUATOR FOR THE LOW-NOISE STOL TEST PLANE FLIGHT CONTROL SYSTEM AND ITS DEVELOPMENT TEST [TEISOUON SUTORU JIKKENKI HIKOU SEIGYO SHISUTEMU YOU AKUCHUETA TO SONOKAIHATSU GIJUTSU SHIKEN]
May 1987 172 p In JAPANESE
(NAL-TM-574; ISSN-0452-2892; JTN-90-80003) Copyright
Avail: NTIS HC/MF A08

In total, 54 actuators (28 types) are used for the flight control system of the low-noise experimental STOL craft. Prior to application to the experimental craft, a development technology test was carried out on the parts other than the C-1 common parts of these actuators. The test was composed of a function and performance test which consisted in confirming the adaptability of the parts to the requirements of the craft on the one hand, and of a weather proofing test which consisted in verifying their adaptability to the operational circumstances of the craft on the other hand. This report explains the general characters of all the actuators used initially for the experimental STOL craft as well as the summary of the results of the development technology test carried out. NASDA

N91-10039*# College of William and Mary, Williamsburg, VA. Dept. of Computer Science.
AUTOMATIC DETERMINATION OF FAULT EFFECTS ON AIRCRAFT FUNCTIONALITY Semiannual Progress Report, 17 Feb. - 17 Aug. 1989
STEFAN FEYOCK 1989 40 p
(Contract NCC1-122)
(NASA-CR-181352; NAS 1.26:181352) Avail: NTIS HC/MF A03
CSCL 01/3

The problem of determining the behavior of physical systems subsequent to the occurrence of malfunctions is discussed. It is established that while it was reasonable to assume that the most important fault behavior modes of primitive components and simple subsystems could be known and predicted, interactions within composite systems reached levels of complexity that precluded the use of traditional rule-based expert system techniques. Reasoning from first principles, i.e., on the basis of causal models of the physical system, was required. The first question that arises is, of course, how the causal information required for such reasoning should be represented. The bond graphs presented here occupy a position intermediate between qualitative and quantitative

models, allowing the automatic derivation of Kuipers-like qualitative constraint models as well as state equations. Their most salient feature, however, is that entities corresponding to components and interactions in the physical system are explicitly represented in the bond graph model, thus permitting systematic model updates to reflect malfunctions. Researchers show how this is done, as well as presenting a number of techniques for obtaining qualitative information from the state equations derivable from bond graph models. One insight is the fact that one of the most important advantages of the bond graph ontology is the highly systematic approach to model construction it imposes on the modeler, who is forced to classify the relevant physical entities into a small number of categories, and to look for two highly specific types of interactions among them. The systematic nature of bond graph model construction facilitates the process to the point where the guidelines are sufficiently specific to be followed by modelers who are not domain experts. As a result, models of a given system constructed by different modelers will have extensive similarities. Researchers conclude by pointing out that the ease of updating bond graph models to reflect malfunctions is a manifestation of the systematic nature of bond graph construction, and the regularity of the relationship between bond graph models and physical reality. Author

N91-10040*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.

PROJECT HYBUJET Final Report

TOM RAMSAY, BILL COLLET, KARYN IGAR, DEWAYNE KENDALL, DAVE MIKLOSOVIC, ROBYN REUSS, MARK RINGER, and TONY SCHEIDT May 1990 166 p Prepared in cooperation with Universities Space Research Association, Houston, TX Sponsored by NASA

(NASA-CR-187011; NAS 1.26:187011) Avail: NTIS HC/MF A08 CSCL 01/3

A conceptual Hypersonic Business Jet (HyBuJet) was examined. The main areas of concentration include: aerodynamics, propulsion, stability and control, mission profile, and atmospheric heating. In order to optimize for cruise conditions, a waverider configuration was chosen for the high lift drag ratio and low wave drag. The leading edge and lower surface of a waverider was mapped out from a known flow field and optimized for cruising at Mach 6 and at high altitudes. The shockwave generated by a waverider remains attached along the entire leading edge, allowing for a larger compression along the lower surface. Three turbofan ramjets were chosen as the propulsion of the aircraft due to the combination of good subsonic performance along with high speed propulsive capabilities. A combination of liquid silicon convective cooling for the leading edges with a highly radiative outer skin material was chosen to reduce the atmospheric heating to acceptable level. Author

N91-10041*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.

OVRHYP, SCRAMJET TEST AIRCRAFT Final Report

J. ASLAN, T. BISARD, S. DALLINGA, K. DRAPER, G. HUFFORD, W. PETERS, and J. ROGERS May 1990 127 p Prepared in cooperation with Universities Space Research Association, Houston, TX Sponsored by NASA

(NASA-CR-187009; NAS 1.26:187009) Avail: NTIS HC/MF A07 CSCL 01/3

A preliminary design for an unmanned hypersonic research vehicle to test scramjet engines is presented. The aircraft will be launched from a carrier aircraft at an altitude of 40,000 feet at Mach 0.8. The vehicle will then accelerate to Mach 6 at an altitude of 100,000 feet. At this stage the prototype scramjet will be employed to accelerate the vehicle to Mach 10 and maintain Mach 10 flight for 2 minutes. The aircraft will then decelerate and safely land. Author

N91-10042# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.

ROTORCRAFT DRIVETRAIN LIFE SAFETY AND RELIABILITY

DEREK G. ASTRIDGE, ed. and M. SAVAGE, ed. (Akron Univ., OH.) Jun. 1990 83 p

(AGARD-R-775; ISBN-92-835-0540-9; AD-A226496) Copyright Avail: NTIS HC/MF A05; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

This is a portion of a intended volume on Transmission Systems for Power Transfer in Helicopters and Turboprops. Lessons learned from accident data of large civil transport helicopters are examined, as are recent improvements in design and component technology, including recommendations and safety benefits achievable by monitoring systems. A statistical analysis was made of drive system life and reliability. A proper evaluation was made of drive systems design and the understanding and control of mean life and life scatter of a drive system at the design stage.

N91-10043# Astridge (Derek) and Associates, Langport (England).

HELICOPTER TRANSMISSIONS: DESIGN FOR SAFETY AND RELIABILITY

DEREK G. ASTRIDGE *In* AGARD, Rotorcraft Drivetrain Life Safety and Reliability p 1-34 Jun. 1990 Previously announced in IAA as A90-20608

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An analysis of the UK CAA's world wide helicopter accident data indicates that transmissions accounted for 22 percent of potentially airworthiness related accidents in civil helicopters of more than 4550 kg gross weight. An evaluation is made of design and technology advancements over the last decade which should benefit helicopter transmission safety and reliability. These encompass improved steels with superior fatigue performance, S/N curve refinement, computer aided design analysis systems, CAD/CAM, improved lubricants and filtration systems, and expert systems retaining a collective memory with regard to design practices' relationship to service experience. E.R.

N91-10044# Akron Univ., OH.

DRIVE SYSTEM LIFE AND RELIABILITY

M. SAVAGE *In* AGARD, Rotorcraft Drivetrain Life Safety and Reliability p 35-71 Jun. 1990

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Fuel efficiency is an important objective in aircraft propulsion. In design, the requirements of light weight and high reliability conflict. Designers use highly stressed, high quality alloy steels in the major load bearing components to resolve the conflict. One estimate for the service needs of a drive system comes from its life and reliability models. The design objectives of long life between repairs and high reliability are design goals. The statistics of drive system life and reliability are discussed. The statistics develop reliability models for repair prediction. The modes of failure which are the basis for these models are also discussed. Coverage of the two parameter Weibull distribution model for component and system life is detailed. Similar coverage is made of the Miner Palmgren load-life model. Based on this model, the theory of mission spectrum averaging is presented. Mission spectrum averaging determines the equivalent constant load which has the same life as the mission spectrum. Also the component life and reliability models for bearings and gears are described. On-board monitoring systems are described. Estimates of the drive system failure rate and replacement needs are still essential at the design stage. E.R.

N91-10045*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ROTOR SYSTEMS RESEARCH AIRCRAFT RISK-REDUCTION SHAKE TEST

J. BRENT WELLMAN Washington Aug. 1990 356 p

(NASA-TM-4186; A-88316; NAS 1.15:4186;

AVSCOM-TR-88-A-003) Avail: NTIS HC/MF A16 CSCL 01/3

A shake test and an extensive analysis of results were performed to evaluate the possibility of and the method for dynamically calibrating the Rotor Systems Research Aircraft

(RSRA). The RSRA airframe was subjected to known vibratory loads in several degrees of freedom and the responses of many aircraft transducers were recorded. Analysis of the transducer responses using the technique of dynamic force determination showed that the RSRA, when used as a dynamic measurement system, could predict, a posteriori, an excitation force in a single axis to an accuracy of about 5 percent and sometimes better. As the analysis was broadened to include multiple degrees of freedom for the excitation force, the predictive ability of the measurement system degraded to about 20 percent, with the error occasionally reaching 100 percent. The poor performance of the measurement system is explained by the nonlinear response of the RSRA to vibratory forces and the inadequacy of the particular method used in accounting for this nonlinearity. Author

N91-10046# Oak Ridge National Lab., TN. Center for Transportation Analysis.
ENERGY EFFICIENCY IMPROVEMENT POTENTIAL OF COMMERCIAL AIRCRAFT TO 2010
DAVID L. GREENE Jun. 1990 42 p
(Contract DE-AC05-84OR-21400)
(DE90-014767; ORNL-6622) Avail: NTIS HC/MF A03

Aircraft are second only to motor vehicles in the use of motor fuels. Furthermore, air travel is growing twice as fast as highway travel. Clearly, the importance of energy use by commercial aircraft will continue to increase. Since 1970, air travel has more then tripled, but the growth of fuel use has been restrained by a near doubling of efficiency, from 26.2 seat miles per gallon (SMPG) in 1970 to about 49 SMPG in 1989. This paper explores the potential for future efficiency improvements via the replacement of existing aircraft with 1990's generation and post 2000 aircraft incorporating advances in engine and airframe technology. Today, new commercial passenger aircraft deliver 50 to 70 SMPG. New aircraft types scheduled for delivery in the early 1990's are expected to achieve 65 to 80 SMPG. Industry and government researchers have identified technologies capable of boosting aircraft efficiencies to the 100 to 150 SMPG range. Under current industry plans, which do not include a post-2000 generation of new aircraft, the total aircraft fleet should reach the vicinity of 65 SMPG by 2010. A new generation of 100 to 150 SMPG aircraft introduced in 2005 could raise the fleet average efficiency to 75 to 80 SMPG in 2010. In any case, fuel use will likely continue to grow at from 0.8 percent/y to 1.8 percent/y through 2010. DOE

N91-10047*# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
NONLINEAR FEEDBACK CONTROL FOR HIGH ALPHA FLIGHT Final Report, Jan. 1989 - Apr. 1990
HAROLD STALFORD Apr. 1990 15 p
(Contract NAG1-959)
(NASA-CR-186545; NAS 1.26:186545) Avail: NTIS HC/MF A03 CSCL 01/3

Analytical aerodynamic models are derived from a high alpha 6 DOF wind tunnel model. One detail model requires some interpolation between nonlinear functions of alpha. One analytical model requires no interpolation and as such is a completely continuous model. Flight path optimization is conducted on the basic maneuvers: half-loop, 90 degree pitch-up, and level turn. The optimal control analysis uses the derived analytical model in the equations of motion and is based on both moment and force equations. The maximum principle solution for the half-loop is poststall trajectory performing the half-loop in 13.6 seconds. The agility induced by thrust vectoring capability provided a minimum effect on reducing the maneuver time. By means of thrust vectoring control the 90 degrees pitch-up maneuver can be executed in a small place over a short time interval. The agility capability of thrust vectoring is quite beneficial for pitch-up maneuvers. The level turn results are based currently on only outer layer solutions of singular perturbation. Poststall solutions provide high turn rates but generate higher losses of energy than that of classical sustained solutions. Author

N91-10049*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
BODY WEIGHT OF HYPERSONIC AIRCRAFT, PART 1
MARK D. ARDEMA Oct. 1988 62 p
(NASA-TM-101028; A-88279-PT-1; NAS 1.15:101028) Avail: NTIS HC/MF A04 CSCL 01/3

The load bearing body weight of wing-body and all-body hypersonic aircraft is estimated for a wide variety of structural materials and geometries. Variations of weight with key design and configuration parameters are presented and discussed. Both hot and cool structure approaches are considered in isotropic, organic composite, and metal matrix composite materials; structural shells are sandwich or skin-stringer. Conformal and pillow-tank designs are investigated for the all-body shape. The results identify the most promising hypersonic aircraft body structure design approaches and their weight trends. Geometric definition of vehicle shapes and structural analysis methods are presented in appendices. Author

N91-10051# Federal Aviation Administration, Atlantic City, NJ.
STRUCTURAL TESTS OF AIRCRAFT WINDOW ASSEMBLY EQUIPPED WITH SMOKE EVACUATION VALVE
ANTHONY WILSON and WILLIAM CAVAGE, JR. Sep. 1990 20 p
(DOT/FAA/CT-TN89/44) Avail: NTIS HC/MF A03

The results of three tests performed on a window and window frame of a Boeing 707 are presented. The purpose of the test, conducted at the Federal Aviation Administration Technical Center, was to determine the maximum moment the window could withstand before becoming dislodged from its frame due to the failure of the window retention clips. The window assembly was modified to fit into a load machine. The loads were measured with a load cell and recorded on a Honeywell Test Management System. Author

N91-10052# Federal Aviation Administration, Atlantic City, NJ.
AIRPLANE SYSTEMS MODIFICATIONS FOR IMPROVED CABIN SMOKE EVACUATION
THOR I. EKLUND Sep. 1990 20 p
(DOT/FAA/CT-TN90/24) Avail: NTIS HC/MF A03

Two concepts for improved aircraft in-flight smoke evacuation were analyzed and tested. The concept definition and evaluation efforts involved an additional ventilation outflow valve on the aircraft underside along with either increased ventilation air volume from the engine compressors or a supplemental ram air supply. Subsequent test aircraft modification involved addition of a pressure controlling outflow valve on the top of the fuselage and upgraded engine bleed air volume flow for cabin air-conditioning. Ground and flight tests were conducted on a test B757 with buoyant and nonbuoyant theatrical smokes generated continuously in various places in the passenger cabin. Buoyant smoke could be localized only when generated in the vicinity of the upper lobe outflow valve. Nonbuoyant smoke could be localized only when generated in the vicinity of an outflow valve, whether the valve was on the top or bottom of the fuselage. The buoyant smoke was formulated to have the same type flow behavior as a plume from the visible flames of a burning surface. The nonbuoyant smoke might be more representative of a smoldering material. Author

N91-10053# National Aerospace Lab., Tokyo (Japan).
A CONSIDERATION ON FLIGHT PATHS FOR MICROWAVE-POWERED AIRPLANES
KINGO TAKASAWA and FUMIKO ITOH Jan. 1990 30 p In JAPANESE; ENGLISH summary
(NAL-TR-1051; ISSN-0389-4010) Avail: NTIS HC/MF A03

Flight paths for microwave-powered airplanes were investigated under uniform wind conditions. Some techniques for deducing flight paths are discussed. The loci of airspeed vectors which lead to preferable flight paths are sorted into four types. The effects of added higher harmonic components are discussed. For each type of airspeed vector loci, three kinds of solving methods are applied and 12 solutions are obtained. Examples of flight paths are

illustrated with their mathematical expressions, and characteristics are discussed. Preferable flight paths from the view point of airplane design are described. Author

N91-10054# National Aerospace Lab., Tokyo (Japan).
PRACTICAL FLIGHT PATHS FOR MICROWAVE-POWERED AIRPLANES
TAKESHI ITO Jan. 1990 15 p
(NAL-TR-1052T; ISSN-0389-4010) Avail: NTIS HC/MF A03

Although some types of closed flight paths have been proposed for microwave powered airplanes, they have unfavorable features from the viewpoint of airplane designers, especially under strong wind conditions. Here, by working out several methods of defining the airspeed vector, smooth practical periodic flight paths are deduced. Author

N91-10055# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Helicopter Div.
MBB'S BO 108 DESIGN AND DEVELOPMENT
HELMUT B. HUBER and CLAUS SCHICK May 1990 15 p Presented at 46th American Helicopter Society Annual Forum and Technology Display, Washington, DC, 21-23 May 1990
(MBB-UD-0568-90-PUB; ETN-90-97838; OTN-027636) Avail: NTIS HC/MF A03

The development by MBB of a new light twin, multipurpose helicopter, designated as the BO-108 is described. The design requirements and the technology advances in terms of the various components involved (rotor systems, drive system, anti-vibration system, control system, airframe, cockpit and cabin) are presented. An overview on the current status of bench and in-flight testing is given and the progress achieved in the fields of performance, flying qualities, noise and vibrations, weight, reliability and safety is assessed. Studies for increasing the aircraft's capabilities are described and a prospective about the future program plans is given. ESA

N91-10056# Rolls-Royce Ltd., Bristol (England).
PROGRESS IN CERTIFYING F402-RR-408: THE IMPROVED PEGASUS ENGINE FOR AV-8B AND HARRIER 2 PLUS
DAVID J. MARTIN Derby, England 19 Sep. 1989 10 p Presented at Tactical V/STOL Aircraft, New Bern, NC, 19-21 Sep. 1989 Sponsored by Ministry of Defence, London, England
(PNR-90719; ETN-90-97945) Copyright Avail: NTIS HC/MF A02

The operational background of the Harrier/AV8 family of aircraft was used to define a demonstrator program for improved performance. The XG15 demonstrator program was completed in April 1988. The results formed the basis of the improved F402-RR-408 engine. The validation test program commenced with an engine roll out in June 1988 and is due for completion in May 1990. A summary of technical issues and program status is given. ESA

N91-10932# Deutsche Airbus G.m.b.H., Bremen (Germany, F.R.).
A QUARTER OF A CENTURY OF AEROELASTIC COOPERATION BETWEEN RESEARCH AND INDUSTRY (A REVIEW). PART 2: TRANSPORT AIRPLANES AND OTHER CIVIL APPLICATIONS
S. VOGEL, H. ZIMMERMANN, and K. KOENIG *In* DLR, Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 271-287 Apr. 1990
Avail: NTIS HC/MF A13

Studies and developments in the field of civil aviation by the German aircraft industry and the DLR Institute of Aeroelasticity are described. The application of aerolasticity to wind turbine systems for energy supply is outlined. Aeroservoelasticity and active control technology are introduced. Methods for the calculation of unsteady aerodynamic forces in the transonic domain are presented. The measurement of unsteady aerodynamic loads is discussed. ESA

N91-10937*# Boeing Commercial Airplane Co., Seattle, WA.
BOEING FLIGHT DECK DESIGN PHILOSOPHY
HARTY STOLL *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 17-25 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Information relative to Boeing flight deck design philosophy is given in viewgraph form. Flight deck design rules, design considerations, functions allocated to the crew, redundancy and automation concerns, and examples of accident data that were reviewed are listed. Author

N91-10939*# Douglas Aircraft Co., Inc., Long Beach, CA.
DOUGLAS FLIGHT DECK DESIGN PHILOSOPHY
PAUL OLDALE *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 45-53 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

The systems experience gained from 17 years of DC-10 operation was used during the design of the MD-11 to automate system operation and reduce crew workload. All functions, from preflight to shutdown at the termination of flight, require little input from the crew. The MD-11 aircraft systems are monitored for proper operation by the Aircraft Systems Controllers (ASC). In most cases, system reconfiguration as a result of a malfunction is automated. Manual input is required for irreversible actions such as engine shutdown, fuel dump, fire agent discharge, or Integrated Drive Generator (IDG) disconnect. During normal operations, when the cockpit is configured for flight, all annunciators on the overhead panel will be extinguished. This Dark Cockpit immediately confirms to the crew that the panels are correctly configured and that no abnormalities are present. Primary systems annunciations are shown in text on the Alert Area of the Engine and Alert Display (EAD). This eliminates the need to scan the overhead. The MD-11 aircraft systems can be manually controlled from the overhead area of the cockpit. The center portion of the overhead panel is composed of the primary aircraft systems panels, which include FUEL, AIR, Electrical (ELEC) and Hydraulic (HYD) systems, which are easily accessible from both flight crew positions. Each Aircraft Systems Controller (ASC) has two automatic channels and a manual mode. All rectangular lights are annunciators. All square lights are combined switches and annunciators called switch/lights. Red switch/lights on the overhead (Level 3 alerts) are for conditions requiring immediate crew action. Amber (Level 2 or Level 1 alerts) indicates a fault or switch out of position requiring awareness or crew interaction. Overhead switches used in normal operating conditions will illuminate blue when in use (Level 0 alerts) such as WING ANTI-ICE - ON. An overhead switch/light with BLACK LETTERING on an amber or red background indicates a system failure and that crew interaction is required. A switch/light with blue or amber lettering and a BLACK BACKGROUND indicates a switch out of normal position and that crew action is necessary only if the system is in manual operation. Author

N91-10949*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OVERVIEW OF ERROR-TOLERANT COCKPIT RESEARCH
Abstract Only
KATHY ABBOTT *In its* Aviation Safety/Automation Program Conference p 153-156 · Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

The objectives of research in intelligent cockpit aids and intelligent error-tolerant systems are stated. In intelligent cockpit aids research, the objective is to provide increased aid and support to the flight crew of civil transport aircraft through the use of artificial intelligence techniques combined with traditional automation. In intelligent error-tolerant systems, the objective is to develop and evaluate cockpit systems that provide flight crews with safe and effective ways and means to manage aircraft systems, plan and replan flights, and respond to contingencies. A subsystems fault management functional diagram is given. All information is in viewgraph form. Author

N91-10969# Technische Univ., Brunswick (Germany, F.R.).
COMPARISON OF A MATHEMATICAL ONE-POINT MODEL AND A MULTI-POINT MODEL OF AIRCRAFT MOTION IN MOVING AIR
R. BROCKHAUS *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 17 p Mar. 1990
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The steadily growing capacity of computers favors increasingly exact simulation of even complex processes. On the other hand, parameter identification and state estimation require much more precise models than are generally used for the design of feedback systems. A multi-point model of the aircraft motion is proposed in which the different coupling effects between the two sub-processes, aircraft and air flow, can be modeled with much higher accuracy than is obtained by using the ordinary one-point model, where all the force, moment, and velocity vectors are referred to the aircraft center of gravity. The modeling of the effects of aircraft rotation, wing down-wash, wind gradients, and other unstationary effects should be greatly improved by a multi-point approach, provided that the aerodynamic effects on the aircraft components can be described appropriately. The nonlinear equations of the total process are set up for the one-point and multi-point models and compiled into block diagrams, from which the physical background of the interrelations between air and aircraft motion can be seen very clearly. The possible improvement in model quality and the additional computer capacity needed are estimated by comparing the two approaches. Author

N91-10971# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
CRITICAL ASPECTS OF TRAJECTORY PREDICTION: FLIGHT IN NON-UNIFORM WIND
BERNARD ETKIN and DAVID ALEXANDER ETKIN (Canadian Climate Centre, Downsview, Ontario) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 12 p Mar. 1990
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The genesis of natural wind is described from a meteorological standpoint. Its influence on aircraft trajectories is discussed with reference to steady winds, turbulence, and wind shear. The main problems exist when flight is close to the ground, during landing, take-off, or terrain following. A model for analysis and simulation is presented consisting of four components - dynamics, kinematics and transformations, aerodynamics, and wind. The axis systems chosen are well suited to simulation of landing and take-off. Author

N91-10972# Technische Univ., Brunswick (Germany, F.R.). Inst. of Flight Guidance and Control.
EFFECT OF WIND AND WIND VARIATION ON AIRCRAFT FLIGHT-PATHS
K.-U. HAHN, T. HEINTSCH, B. KAUFMANN, G. SCHAENZER, and M. SWOLINSKY *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 27 p Mar. 1990 Sponsored by DFG
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Wind shear accidents during landing and approach could generally be avoided by using modern flight control systems. The problem is to inform the pilot by an adequate wind shear warning display, that he can understand the reaction of the control system. Wind shear is particularly dangerous if it occurs in a height of approximately 80 to 120 m, where the attention of the cockpit crew is affected by getting view contact to the ground. Wind shear during take-off and go-around is a pure flight performance problem. Pilots should avoid a take-off into a thunderstorm. In moderate downbursts a practicable escape maneuver is to maintain the flight level at a low height to pass the core of the downburst before starting the climb. This procedure can also be applied on the go-around. Author

N91-10973# Southampton Univ. (England).
AIRCRAFT FLIGHT IN WIND-SHEAR
D. MCLEAN *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 10 p Mar. 1990
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A brief account of wind-shear and some representations is given before discussing the effects of wind-shear on aircraft motion. A procedure for estimating the vertical and horizontal velocity components of a wind-shear microburst, based on observer theory is developed, and a brief discussion of flying in wind-shear concludes the paper. Author

N91-10974# Airbus Industrie, Blagnac (France).
HOW TO FLY WINDSHEAR
PAUL CAMUS *In* Agard, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 10 p Mar. 1990
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Aviation safety history is a long fight against severe environmental constaint: Modern aircraft are able to face safely most of them but one still remains a potential killer, that is what is generally described as a windshear situation. What can be done, necessarily fall either in how to timely detect such a situation in order to avoid it or/and what tools could be given to the crew to better escape should they are trapped in. Latest state of build-in equipment, 3-D Navigation, electronic displays and flight control, provide now all necessary tools to develop an efficient in-board detection and protection system. Such a system will be described altogether with a review of some fundamental criteria to be considered when assessing their efficiency. Author

N91-10976# Smiths Industries, Inc., Grand Rapids, MI.
AIRCRAFT TRAJECTORY: PREDICTION AND CONTROL IN THE AIR TRANSPORT FLIGHT MANAGEMENT COMPUTER SYSTEMS
PETER J. HOWELLS *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 13 p Mar. 1990
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The declining cost of computing power and memory has enabled avionic manufacturers to develop sophisticated airborne computing systems. One of the most complex aircraft systems on modern air transport aircraft is the Flight Management Computer System (FMCS). The FMCS has reduced pilot workload by taking over the more mundane but complex functions, such as calculating the most economical speed, and, together with improvements in cockpit displays and monitoring systems, has allowed the transition from the three to two crew airline cockpit. The FMCS can compute the most economical path from one airport to another and then fly the aircraft along that path. To achieve this the computer must be able to select the most economical speed schedules for each phase of flight, then predict the complex vertical and horizontal profile that the aircraft would fly and, when connected to the aircraft's autopilot, control the aircraft along that three dimensional flight path. The forth dimension of time can also be selected as a control criteria, and the FMCS will compute the speed schedules and flight path based on a required time of a arrival at a selected point along the flight plan. In addition to reducing pilot workload, air traffic control efficiency is increased because the airborne

navigation data base can be used to select and accurately fly published arrival and departure procedures without supervision from the ground controllers. The algorithms used for the Smiths Industries 737 FMCS prediction and control functions are described. The requirements for successful implementation and some of the difficulties that may be encountered are identified. Author

N91-10981# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.

AIRCRAFT TRAJECTORIES: COMPUTATION, PREDICTION, CONTROL, VOLUME 2: AIR TRAFFIC HANDLING AND GROUND-BASED GUIDANCE OF AIRCRAFT. PART 4: AIR TRAFFIC HANDLING. PART 5: GUIDANCE OF AIRCRAFT IN A TIME-BASED CONSTRAINED ENVIRONMENT. PART 6: SURVEILLANCE. PART 7: METEOROLOGICAL FORECASTS. PART 8: AIRCRAFT OPERATION IN AIR TRAFFIC HANDLING SIMULATION

ANDRE BENOIT, ed. May 1990 453 p In ENGLISH and FRENCH

(AGARD-AG-301-VOL-2-PT-4-8; ISBN-92-835-0562-X; AD-A225265) Copyright Avail: NTIS HC/MF A20; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

This volume (part of a set of three) is composed of a preface and 28 papers covering respectively, the following topics. (1) Air traffic handling: Integration of control phases; A future European ATC concept; On-line prediction of aircraft trajectories; and Air traffic management. (2) Guidance of aircraft in a time based constrained environment: Guidance and control principles and concepts; Conduct of Air Traffic Control in a Zone of Convergence; Ground-based 4-D guidance of aircraft in moving atmosphere; and The Computer/Controller/Pilot dialogs. (3) Surveillance: Radar tracking; and Satellite techniques. (4) Meteorological forecasts: Impact of forecasts quality on trajector prediction; and Flight operations within a terminal area. (5) Aircraft operation in air traffic handling simulation: Realistic operation and motion of aircraft; and Flight operations within a terminal area.

N91-10984# Royal Radar Establishment, Malvern (England).

PREDICTION OF AIRCRAFT TRAJECTORIES

STANLEY RATCLIFFE *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 40 p May 1990

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Air traffic management, in designing route structures, drawing up rules for flight in various types of airspace, and in framing the instructions for air traffic controllers, are concerned with predicting the behavior, often on worst case assumptions, of each class of traffic with which they may have to deal. The problems are examined of on-line trajectory prediction to a time-horizon perhaps a little longer than the estimated time of the flight or as short as a few tens of seconds, the object being to predict and avoid collision with terrain or with another aircraft, and to ensure that any in-flight delays due to traffic congestion along the route are absorbed as economically as possible. Military aircraft are concerned with the avoidance of anti-aircraft missiles and in intercepting airborne targets. This latter problem may, very loosely, be regarded as collision avoidance in reverse, and is briefly discussed, as is the problem of terrain-following by high performance low flying military aircraft. The conclusion draws attention to areas where further R and D would seen desirable. Author

N91-10985# Universite Catholique de Louvain (Belgium). Dept. de Mecanique.

AIRCRAFT DYNAMICS FOR AIR TRAFFIC CONTROL

P.-Y. WILLEMS *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 19 p May 1990

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The equations of motion of airplanes in the context of Air Traffic Control (ATC) are discussed. The basic laws of mechanics are examined together with a mathematical model of mechanical systems which is suitable for airborne systems; the generally accepted (but often implicit) assumptions of usual models are pointed out. A simplified description of the main dynamical effects (gravity and aerodynamical interactions) are given together with a complete kinematical description of the system. The coherence with ISO norms (ISO - 1985) are respected as far as possible; some dynamical short commings of these norms are mentioned. Author

N91-10987# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.

GENERATION OF AIRCRAFT TRAJECTORIES FOR ON-LINE OPERATION: METHODS, TECHNIQUES, AND TOOLS

ANDRE BENOIT and SIP SWIERSTRA *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Habdling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 12 p May 1990

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An appreciable amount of work has been conducted at the EUROCONTROL Agency's Engineering Directorate in the division engaged in the Study of Long Term Air Traffic Control (ATC) System Requirements in order to generate accurate aircraft trajectory predictions for use in both ATC on-line operation and real time simulations in current and realistic conditions, human interfaces included. The basic approach developed for two distinct classes of application are outlined: (1) the on-line generation of predictions for use in actual operation and, accessorily, real time ATC simulations; and (2) the introduction of realistic aircraft response and motion into ATC simulations, with pilot/auto-pilot interfaces included. Author

N91-11009 Kansas Univ., Lawrence.

CALCULATION OF AERODYNAMIC CHARACTERISTICS OF AIRPLANE CONFIGURATIONS AT HIGH ANGLE OF ATTACK IN STEADY AND UNSTEADY FLOW Ph.D. Thesis

HOMAYOUN EMDAD 1989 117 p

Avail: Univ. Microfilms Order No. DA9024169

A computational method for steady and unsteady lateral directional aerodynamics of fighter configurations is developed. The leading-edge vortices are represented by free vortex filaments which are adjusted iteratively to satisfy the force-free condition. The forebody vortex separation, both symmetrical and asymmetrical, is calculated with slender body theory. The effect of the boundary layer separation on lifting surfaces is accounted for by using the effective sectional angles of attack. Results for several fighter configurations are employed for comparison with available data. It is shown that the present steady-flow method produces reasonable results in predicting slideslip derivatives, while roll- and yaw-rate derivatives do not compare very well with forced-oscillation test data at high angles of attack. To account for unsteady aerodynamics, a theoretical method is developed to determine the aerodynamic derivatives due to pitching, plunging, flapping, side movement, rolling, and yawing for a wing in a compressible flow. The present method is based on the frequency approach, instead of time-domain integration. The wing is represented by a series of oscillatory horseshoe vortices, and the leading-edge vortices are represented by oscillatory line vortices. Results for 60 and 80 deg delta wings are compared with

experimental data. It is shown that the present method produces reasonable results for roll damping derivatives before occurrence of vortex breakdown. Other dynamic derivatives were not compared. Dissert. Abstr.

N91-11010 Purdue Univ., West Lafayette, IN.
DEVELOPMENT AND APPLICATION OF THE TIME DOMAIN PANEL METHOD Ph.D. Thesis
MAXWELL BLAIR 1989 196 p
Avail: Univ. Microfilms Order No. DA9018788

The utility of the Time Domain Panel (TDP) algorithm for wing design and analysis is developed and demonstrated. This is a linear unsteady aerodynamic method for simulating loads on an oscillating wing in subsonic compressible flow. This time stepping simulation is based on Guderley's integral formulae. Other current work, which is similar in application, is either based on computationally expensive nonlinear finite difference schemes, or is based on inverse transforms of linear harmonic aerodynamic loads. The TDP method is a direct integral (panel) method which has the efficiency of linear aerodynamics but is in a suitable form for developing simulation models with nonlinear structural dynamics or nonlinear controls. This is a linear time stepping method which falls between linear harmonic aerodynamic methods and higher order nonlinear time stepping aerodynamic methods. The developmental details in numerically implementing Guderley's integral formula is given here. Several applications are presented in order to provide confidence that the TDP method is practical and numerically accurate. Dissert. Abstr.

N91-11011 Stanford Univ., CA.
CONTROLLED VORTICAL FLOW ON DELTA WINGS THROUGH UNSTEADY LEADING EDGE BLOWING Ph.D. Thesis
KYUNG-TAE LEE 1990 147 p
Avail: Univ. Microfilms Order No. DA9024343

The vortical flow over a delta wing contributes an important part of the lift - the so called nonlinear lift. Controlling this vortical flow with its favorable influence would enhance aircraft maneuverability at high angle of attack. Several previous studies have shown that control of the vortical flow field is possible through the use of blowing jets. Vortical flow control is studied by applying a new blowing scheme to the rounded leading edge of a delta wing; this blowing scheme is called Tangential Leading Edge Blowing (TLEB). Vortical flow response both to steady blowing and to unsteady blowing is investigated. It is found that TLEB can redevelop stable, strong vortices even in the post-stall angle of attack regime. Analysis of the steady data shows that the effect of leading edge blowing can be interpreted as an effective change in angle of attack. The examination of the fundamental time scales for vortical flow re-organization after the application of blowing for differential initial states of the flow field is studied. Different time scales for flow re-organization are shown to depend upon the effective angle of attack. A faster response time can be achieved at angles of attack beyond stall by a suitable choice of the initial blowing momentum strength. Consequently, TLEB shows the potential of controlling the vortical flow over a wide range of angles of attack; i.e., in both for pre-stall and post-stall conditions. Dissert. Abstr.

N91-11012 Maryland Univ., College Park.
COUPLED ROTOR/AIRFRAME VIBRATION ANALYSIS Ph.D. Thesis
SHMUEL FLEDEL 1989 171 p
Avail: Univ. Microfilms Order No. DA9021500

A consistent finite-element formulation developed for the prediction of vibration in rotor/body helicopter systems in forward flight, taking into account interactional rotor/body aerodynamic loads and dynamic coupling is presented. The rotor blades are assumed to be elastic beams undergoing flap and lag bending, torsion and axial deflections. The coupled analysis is formulated retaining nonlinear structural, inertial and aerodynamic terms in a consistent manner. Rotor excitation includes rotor/body interactional loads and fuselage dynamic coupling. Effects of several parameters on vibratory hub loads and body vibration are investigated, including blade stiffness, rotor/body clearance, hub location, fuselage stiffness and advance ratio. A significant influence of body upwash on the rotor disk in causing vibratory hub shear is shown, an effect which generally increases with smaller rotor/body clearance. Tuning of rotor and body natural modes substantially reduces vibration levels. Elastic deflections of the body have considerable influence on vibratory hub loads. Analyses assuming clamped body motion (wind tunnel condition) or rigid body motion yield inadequate vibration predictions for the rotor/body system. Dissert. Abstr.

N91-11013 Tennessee Univ., Knoxville.
AERODYNAMIC DESIGN OPTIMIZATION USING COMPUTATIONAL FLUID DYNAMICS Ph.D. Thesis
DAVID HOWARD HUDDLESTON 1989 122 p
Avail: Univ. Microfilms Order No. DA9021023

An aerodynamic design optimization technique is presented that couples direct optimization algorithms with the analysis capability provided by appropriate computational fluid dynamics (CFD) programs. This technique is intended to be an aid in designing the aerodynamic shapes and establishing test conditions required for the successful simulation of aircraft engine inlet conditions in a ground test environment. However, the method is also applicable to other aerodynamic design problems such as airfoil design, turbomachinery cascade design, and nozzle design. The approach involves minimization of a nonlinear least-squares objective function which may be defined in a region remote to the geometric surface being optimized. Finite-difference Euler and Navier-Stokes codes were applied to obtain the objective function evaluations, although the applied optimization method can be coupled with any appropriate CFD analysis technique. Using CFD to compute design space gradients within an optimization algorithm has received little prior attention in the literature. It is demonstrated, that CFD can be used in this manner by applying the developed design technique to a variety of aerodynamic design problems. Results are presented for several typical aerospace examples, including algebraic test functions, inviscid and viscous flow over airfoils, flows in convergent/divergent nozzles in both two and three dimensions, and supersonic flow about a planar forebody simulator. Dissert. Abstr.

N91-11014 California Inst. of Tech., Pasadena.
APPLICATION OF DYNAMICAL SYSTEMS THEORY TO NONLINEAR AIRCRAFT DYNAMICS Ph.D. Thesis
CRAIG CHARLES JAHNKE 1990 281 p
Avail: Univ. Microfilms Order No. DA9022286

A continuation method was used to determine the steady states of three nonlinear aircraft models: a general aviation aircraft with a canard configuration, a generic jet fighter, and the F-14. The continuation method calculated the steady states of the aircraft as functions of the control surface deflections. Bifurcations of these steady states were determined and shown to cause instabilities which resulted in qualitative changes in the state of the aircraft. A longitudinal instability which resulted in a deep stall was determined for the general aviation aircraft. Roll-coupling and high angle of attack instabilities were determined for the generic jet fighter, and wing rock, directional divergence and high angle of attack instabilities were determined for the F-14. Knowledge of the control surface deflections at which bifurcations occurred was used to either put limits on the control surface deflections or to program the control surface deflections at which bifurcations occur could not be attained. Simple control systems were included in the aircraft models to determine the effects of control systems on the instabilities of each aircraft. Steady spin modes were determined for each aircraft. A successful recovery technique was determined for the general aviation aircraft, but no successful recovery technique could be found for the F-14. Dissert. Abstr.

N91-11015# Federal Aviation Administration, Atlantic City, NJ.
GENERATION OF A BUOYANT PLUME OF ARTIFICIAL SMOKE FOR AIRPLANE TESTS Final Report

THOR I. EKLUND Sep. 1990 28 p
(DOT/FAA/CT-90/9) Avail: NTIS HC/MF A03

A buoyant artificial smoke generator was developed for airplane test applications. In the device, theatrical smoke is mixed with a mixture of helium and air. The total gas flow, the helium to air ratio, and the theatrical smoke particulate generation rate can all be varied in the device. A gas mixture of 50 percent each of helium and air has the buoyancy properties of air, alone, heated to 475 F. The device was used in cabin smoke evacuation tests in a modified Boeing 757 aircraft. Generation of the buoyant smoke in an aircraft resulted in dramatically different behavior from that previously observed with nonbuoyant theatrical smoke. The buoyant smoke spread further through the aircraft in a manner that was not predicted by an analytical model on cabin smoke spread. Besides being used to assess airplane cabin smoke evacuation capability, the buoyant smoke generator has been used to evaluate smoke detector performance and optimal location in Air Force jet aircraft. Author

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

N91-10057 National Aerospace Lab., Tokyo (Japan).
WIND TUNNEL TEST OF REDUNDANT VANE-TYPE FLOW-DIRECTION SENSING SYSTEMS [YABANE O MOCHIITA JOUCHOUGATA KIRYUU HOUKOU SOKUTEI SOUCHI NO FUUDOUSHIKEN NI KANSURU HOUKOKU]
TAKEO KIMURA, MINORU TAKIZAWA, TADAO UCHIDA, ATSUTOSHI FUJIEDA, AKIHITO IWASAKI, TOSHIMI FUJITA, and TERUO SOMEYA Jul. 1988 41 p In JAPANESE
(NAL-TM-590; ISSN-0452-2982; JTN-90-80017) Avail: NTIS HC/MF A03

Trial fabrication of a triaxial sensor system, in which alpha is the front angle and beta is the side angles, and performance of wind tunnel tests are presented. An experiment based on the two-dimensional vector volume measurement method using a blast wind tunnel was performed to prove the measurement theory of the triaxial alpha/beta sensor system and to compare the measurement accuracy between the results obtained from a normally functioning sensor and a malfunctioning or out-of-order sensor. Values and errors were calculated from data obtained from three sensors under four different wind velocities of 10, 20, 30, and 40 m/s against a fixed air current of alpha zero beta zero in the wind tunnel. The accuracy of measurement was determined by comparing the measured data with the second and third sensor, first and third sensor, and first and second sensor. The results of the experiment indicated that the measurement of this system was extremely accurate. Even if one of the sensors becomes defective, the accuracy will not reduce the reliability limit as the other sensors functioned normally. Thus the feasibility of this system has been acknowledged. NASDA

N91-10058*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NASA TRANSPORT SYSTEMS RESEARCH VEHICLE B-737 DATA LINK SYSTEM AND DISPLAY FORMATS
CHARLES E. KNOX and CHARLES H. SCANLON Aug. 1990 22 p
(NASA-TM-102717; NAS 1.15:102717) Avail: NTIS HC/MF A03 CSCL 01/3

A data link system was designed to support flight tests in the NASA Transport Systems Research Vehicle B-737 airplane. The purpose of the flight tests was to evaluate pilot acceptance of using data link as the primary source of communications for strategic and tactical air traffic control clearances, weather information, and company messages. The airborne functional operations of the data link system flight tested in 1990 are described. Author

N91-10938*# Honeywell, Inc., Minneapolis, MN.
COCKPIT AVIONICS INTEGRATION AND AUTOMATION
KEITH M. PISCHKE *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 27-44 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Information on cockpit avionics integration and automation is given in viewgraph form, with a number of photographs. The benefits of cockpit integration are listed. The MD-11 flight guidance/flight deck system is illustrated. Author

N91-10942*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUMMARY OF THE INDUSTRY/NASA/FAA WORKSHOP ON PHILOSOPHY OF AUTOMATION: PROMISES AND REALITIES
SUSAN D. NORMAN *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 77-82 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Issues of flight deck automation are multi-faceted and complex. The rapid introduction of advanced computer based technology on to the flight deck of transport category aircraft has had considerable impact on both aircraft operations and the flight crew. As part of NASA's responsibility to facilitate an active exchange of ideas and information between members of the aviation community, an Industry/NASA/FAA workshop was conducted in August 1988. One of the most important conclusions to emerge from the workshop was that the introduction of automation has clearly benefited aviation and has substantially improved the operational safety and efficiency of our air transport system. For example, one carrier stated that they have been flying the Boeing 767 (one of the first aircraft to employ substantial automation) since 1982, and they have never had an accident or incident resulting in damage to the aircraft. Notwithstanding its benefits, many issues associated with the design, certification, and operation of automated aircraft were identified. For example two key conceptual issues were the need for the crew to have a thorough understanding of the system and the importance of defining the pilot's role. With respect to certification, a fundamental issue is the lack of comprehensive human factors requirements in the current regulations. Operational considerations, which have been a factor in incidents involving automation, were also cited. Viewgraphs used in the presentation are given. Author

N91-10950*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
FAULT MONITORING
PAUL SCHUTTE *In its* Aviation Safety/Automation Program Conference p 157-163 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 01/3

Information on fault monitoring of aircraft systems is given in viewgraph form. Information is given on monitor architecture and benefits, implementation characteristics, and an engine monitoring and control system. Author

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A91-10245* Case Western Reserve Univ., Cleveland, OH.
BIFURCATION ANALYSIS OF AXIAL FLOW COMPRESSOR STABILITY
F. E. MCCAUGHAN (Case Western Reserve University, Cleveland, OH) SIAM Journal on Applied Mathematics (ISSN 0036-1399),

vol. 50, Oct. 1990, p. 1232-1253. refs
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With a one-mode truncation it is possible to reduce the Moore-Greitzer model for compressor instability to a set of three ordinary differential equations. These are approached from the point of view of bifurcation theory. Most of the bifurcations emerge from a degenerate Takens-Bogdanov bifurcation point. The bifurcation sets are completed using the numerical branch tracking scheme AUTO. Despite the severity of the truncation, the agreement with experimental results is excellent. Author

A91-10954
DEVELOPMENT OF THE GRIFFON II TURBO-RAMJET [LE DEVELOPPEMENT DU TURBOSTATOREACTEUR DE L'AVION GRIFFON II]
A. GOZLAN IN: *European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 45-52.* In French. refs
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First flight of the experimental Griffon II aircraft in 1957 was the result of seven years of development that began with purely semiempirical research using various ground testing laboratories, wind tunnels, and flying test beds. The turbojet was meant to be utilized principally for takeoff and subsonic acceleration. At about Mach 0.5 the ramjet was started to increase thrust during transonic acceleration and for supersonic flight. The ramjet represented only 30 percent of the total engine weight. Details and graphs are provided of performance realized over the 330 test flights conducted through Mach 2.2 extending over a large flight envelope, restricted only by thermal problems with the aluminum alloy structure. R.E.P.

A91-10958
THE ROLLS ROYCE/SNECMA OLYMPUS 593 ENGINE OPERATIONAL EXPERIENCE AND THE LESSONS LEARNED
G. LAVIEC (SNECMA, Paris, France) and G. GANLEY (Rolls-Royce, PLC, Bristol, England) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 73-80.
Copyright

A review of the 13 years of Concorde engine design and development are presented. Particular attention is devoted to the reliability aspects of this engine running in very severe ambient conditions as compared to a conventional subsonic engine. Specific operational requirements called for an engine to produce sufficient thrust to takeoff with 11 tons of payload for a distance of 3500 nm at Mach 2. To achieve this goal it became necessary to add an afterburner to a conventional twin spool engine and to add a variable secondary nozzle and a thrust reverser. An electronic analog fuel control system was adopted to control the engine to the required turbine inlet temperature appropriate to the thrust required while ensuring that all limitations are not exceeded and that crew handling be minimal. Details and graphs are presented for engine operational experience covering utilization rates, shop visit rates, inflight shutdowns, and the effects of supersonic operations. R.E.P.

A91-10965
SUPERSONIC/HYPERSONIC PROPULSION SYSTEMS - EXHAUST EMISSION CHARACTERISTICS AND ABATEMENT TECHNOLOGY
DONALD W. BAHR (GE Aircraft Engines, Cincinnati, OH) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 167-170.
Copyright

A study of pollutant emissions of aircraft turbine engines is presented. These pollutants consist primarily of smoke, unburned hydrocarbons and oxides of nitrogen. The HC and CO emissions are principally produced at low thrust levels while smoke and NO(x) result mainly from high thrust operating conditions. Continuing technological development has served to radically reduce smoke, HC, and CO emissions so that, at present, cruise NO(x) emissions are the only significant category remaining. Modeling studies show that the NO(x) cruise operating emissions of SST and HST transport aircraft engines may have possible adverse effects on the stratospheric ozone layer. Therefore, the development of SST engine combustors capable of satisfactory operation with significantly reduced NO(x) levels than those of present technology combustors is necessary. R.E.P.

A91-10968
FUTURE SUPERSONIC TRANSPORT PROPULSION OPTIMISATION
B. W. LOWRIE (Rolls-Royce, PLC, Filton, England) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 203-209. refs
Copyright

In order to achieve the optimum cruise performance and airport noise requirements, various variable cycle propulsion systems for a supersonic transport are studied. Fundamental installation requirements show that opportunities to drive the additional flow by turbomachinery can be either front fan, aft fan, or mid fan, and that ejector systems must also be considered. The benefits of these different systems are compared. It is shown that the best projected cruise performance between Mach 2.0 and 2.5 can be achieved with a bypass ratio of 0.8 to 0.5. As a conventional engine of this type produces very high jet velocities at takeoff and adequate silencing is not likely, engines with cycle variability of magnitude much greater than the Olympus 593 are required to swallow greater mass flow and lower jet velocity at takeoff. It is concluded that for an isolated installation the tandem fan engine concept is the best. R.E.P.

A91-10969
THE VARIABLE-CYCLE ENGINE - A SOLUTION TO THE ECONOMICAL AND ENVIRONMENTAL CHALLENGE OF THE FUTURE SUPERSONIC TRANSPORT
ALAIN HABRARD (SNECMA, Paris, France) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 211-218. refs
Copyright

The optimization of a variable-cycle engine designed for the Mach 2 cruise regime is presented. Principal areas of study include specific fuel consumption; the requirements for noise attenuation on the ground, during takeoff and in cruise; by-pass ratios, the reduction of pollutant emissions; adaptive combustors; and a specific variable-cycle engine concept. A variable-cycle engine would have a cycle different for takeoff and subsonic operation from the supersonic regime. As an example, a double-flow cycle with a bypass ratio of 1 to 2 could be used during takeoff while a single-flow cycle would operate in cruise. The specific variable-cycle engine concept discussed corresponds to a good compromise between engine complexity and air inlet/nozzle complexity. Thus it is possible to achieve necessary installed performance and also meet current noise regulations without resorting to new unproven devices. R.E.P.

A91-10975
PROPULSION SYSTEMS FOR HYPERSONIC TRANSPORTATION
J. DARDARE (SEP, Suresnes, France) and P. SENECHAL (SNECMA, Paris, France) IN: *European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 277-279.* refs
Copyright

Propulsion systems for hypersonic transport aircraft are a new challenge for engine manufacturers. High temperatures at the engine inlet, the use of cryogenic fuels, and the necessity of covering a wide range of Mach numbers lead to the use of a

variety of airbreathing engines combining turbo, rocket and ramjet concepts. In France, appropriate studies have been carried out for three years by SNECMA, SEP, and ONERA and aim at defining the propulsion of a winged launcher. This paper presents a selection of the combined engines currently studied which could bring the technologies applicable to the propulsion of a hypersonic transport aircraft. However, mass transportation systems and launcher have quite different requirements, resulting in different optimization criteria which are discussed. Finally, some considerations about environment and installation effects are given. Author

A91-10976
OPTIMISATION OF HYBRID PROPULSION SYSTEMS
R. R. SCHWAB (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, Federal Republic of Germany) and F. A. HEWITT (Rolls-Royce, PLC, Bristol, England) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 282-288. Research supported by ESA. refs
Copyright

Very high speed transport, with cruise at velocities beyond Mach 3, only yields practical returns in saved time for very long ranges (assuming modest levels of acceleration and deceleration). With the probable levels of airframe lift/drag ratio (5-7) and propulsion system specific fuel consumption from Mach 4 onward, this implies major changes in both fueling and powerplant design from those required for subsonic or even supersonic cruise. Powerplant operating in dual modes, with complex interactions between the variable intakes and nozzles and the core engines and burners seem inevitable. This paper discusses some of the installation and optimization aspects of such powerplant, and highlights some of the areas requiring major effort before such systems can be considered. Author

A91-11348
PREDICTION OF TURBULENCE GENERATED RANDOM VIBRATIONAL RESPONSE OF TURBOMACHINERY BLADING
THOMAS E. BOOTH and SANFORD FLEETER (Purdue University, West Lafayette, IN) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 3-4, 1989, p. 247-255. Research sponsored by USAF. refs
Copyright

An analysis is developed to predict the turbulence generated single-degree-of-freedom bending and torsion mode vibrational response of a turbomachine blade row operating in a subsonic compressible flow field. The turbulence is assumed to be random in the neighborhood of the blade natural frequency of interest and to generate a large number of constant amplitude, harmonic, unsteady aerodynamic lift forces and moments on the blading with equally distributed frequencies. The resulting random airfoil vibrations thus occur at the blade natural frequency. The unsteady aerodynamics generated by the blade response, i.e., the aerodynamic damping, as well as the effect of blade aerodynamic coupling are also considered. Author

A91-11349
OPTIMIZATION OF THE ARRANGEMENT OF THE FRONT AND REAR BLADE ROWS OF A TANDEM BLADE CASCADE
GUOCHUAN WU and QI FENG (Nanjing Aeronautical Institute, People's Republic of China) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 3-4, 1989, p. 257-270. refs
Copyright

A simple approximate method is proposed for calculating the minimum-loss relative displacement in the peripheral direction of tandem cascades for any given blade configuration and inlet conditions. Predictions based on the method are found to be in good agrement with experimental results obtained for the Turmo IIIc cascade. In contrast to other method, the approach proposed here avoids the need for calculating the tandem cascade flow field, thus reducing the computational effort. The method has been implemented in software written in FORTRAN IV. V.L.

A91-11351
HOLOGRAPHIC INTERFEROMETRY FOR FLOW VISUALIZATION STUDIES IN HIGH SPEED FANS
R. J. PARKER (Rolls-Royce, PLC, Advanced Research Laboratory, Derby, England) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 6, no. 3-4, 1989, p. 281-303. Research supported by the Ministry of Defence Procurement Executive of England. Previously announced in STAR as N88-28072. refs
Copyright

Holography was developed as a technique for routine use in the evaluation of fan designs for aero-engines. It is used to investigate aerodynamic and mechanical behavior of the rotating fan. Holographic flow visualization provides clear, three-dimensional images of the transonic flow region between the fan blades. Flow features such as shocks, shock/boundary layer interaction, and over-tip leakage vortices can be observed and measured. Examples of the use of this technique at rotational speeds up to and in excess of 10,000 rpm are given. Holography provides valuable information used to verify and improve numerical modeling of the fan behavior and is successful in evaluating the achievement of design intent. Author

A91-12446#
NUMERICAL SIMULATION AND ACTIVE CONTROL OF COMBUSTION INSTABILITY IN A RAMJET COMBUSTOR
SURESH MENON (Quest Integrated, Inc., Kent, WA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 15 p. refs
(Contract N00014-90-C-0089)
(AIAA PAPER 90-3930) Copyright

A large-eddy simulation model has been developed to study combustion instability in a ramjet combustor. A model for premixed combustion is employed in the numerical scheme that explicitly uses the local turbulent flame speed in the governing equation. Combustion instability in the ramjet has been numerically simulated. Two types of instability are observed: a small-amplitude high-frequency instability and a large-amplitude low-frequency instability. Both such instabilities have been experimentally observed, and various computed flow features are in good qualitative agreement with experimental observations. Author

A91-12488#
PROCUREMENT AND TESTING OF A 1/5 SCALE ADVANCED COUNTER ROTATING PROPFAN MODEL
T. J. KIRKER (Rolls-Royce, PLC, Derby, England) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 13 p. refs
(AIAA PAPER 90-3975) Copyright

A 1/5 scale model of an advanced counterrotating propfan engine was designed and manufactured. The model, which incorporates many state-of-the-art measurement techniques used to acquire noise, performance, and detailed aerodynamic data, was designed to allow variations of major design parameters which could influence the performance and/or noise of a propfan powerplant. Samples of test data are presented from three major test series: a series of 'shake-down tests' with no forward speed simulated, to prove the model and all its support systems; the phase I wind tunnel tests, in which basic performance and noise measurements were acquired; and the phase II wind tunnel tests, in which detailed aerodynamic studies were carried out using laser anemometry and holography. I.S.

A91-12524#
SPACE-STRUCTURE DETERMINATION OF THE ACOUSTIC FIELD GENERATED BY A HELICOPTER TURBOSHAFT ENGINE
D. BLACODON and S. LEWY (ONERA, Chatillon, France) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 13 p. Research supported by Service Technique des Programmes Aeronautiques and Turbomeca. refs
(AIAA PAPER 90-4012) Copyright

In order to determine the spinning-mode structure of the acoustic field at each frequency, the nozzle of a Turbomeca TM

333 turboshaft engine was equipped with an array of fixed microphones. Taking into account the problem of high background noise due to the very turbulent internal flow, several methods for data processing are tested by numerical simulations. Among these methods is one based on the angular Fourier transform of the cross-spectral matrix; however, the output noise remains high. An improvement in this method is observed by canceling the diagonal noise terms in the cross-spectral matrix by a three-signal coherent technique. It is shown that the experimental results successfully retrieve the theoretical cut-off properties introduced by the nozzle and the predicted noise generation by the two transonic turbines. R.E.P.

N91-10059 National Aerospace Lab., Tokyo (Japan).
EFFECTS OF COOLANT INJECTION ON TURBINE AERODYNAMIC CHARACTERISTICS. PART 1: TEST TURBINE AND APPARATUS
SHIGEO INOUE, HIROSHI USUI, MITSUHIRO MINODA, and HIROYUKI NOSE May 1988 21 p In JAPANESE; ENGLISH summary
(NAL-TM-585-PT-1; ISSN-0452-2982; JTN-90-80013) Avail: NTIS HC/MF A03

Effects of coolant injection on turbine aerodynamic characteristics were investigated with a test turbine. The main air flow was unheated and the temperature was about 100 C. The coolant (secondary air) temperature was kept at about 100 C, nearly the same as that of the main flow. The present investigation is concerned with effects of coolant injected from the following parts on turbine aerodynamic characteristics: (1) stator blades, (2) both stator and rotor blades, (3) stator casing, and (4) rotor casing (shroud ring). The test facility, the test turbine, and the measuring systems are described. NASDA

N91-10060 National Aerospace Lab., Tokyo (Japan).
EXPERIMENTAL INVESTIGATION ON THE EFFECT OF COOLANT INJECTION ON TURBINE AERODYNAMIC CHARACTERISTICS. PART 2: EFFECTS OF INJECTION FROM ROTOR CASING WITH 30 DEG SLANTED HOLES
HIROSHI USUI, SHIGEO INOUE, MITSUHIRO MINODA, and HIROYUKI NOUSE Jun. 1988 25 p In JAPANESE; ENGLISH summary
(NAL-TM-587-PT-2; ISSN-0452-2982; JTN-90-80014) Avail: NTIS HC/MF A03

Using a test turbine, the effect of coolant injection was investigated on turbine aerodynamic characteristics. The effects of the coolant injection from a rotor casing with 30 deg slanted holes are described. The discussed turbine efficiency introduced is based on torque, rotational speed, mass flow rate, and the radial and tangential distributions of total pressure and flow angles. It may be concluded that there are some reductions in total pressure losses and increases in outlet flow angles in the tip region caused by the coolant injection. NASDA

N91-10061*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
SUPERSONIC COMBUSTION ENGINE TESTBED, HEAT LIGHTNING Final Report
D. HOYING, C. KELBLE, A. LANGENBAHN, M. STAHL, M. TINCHER, M. WALSH, and S. WISLER May 1990 112 p Prepared in cooperation with Universities Space Research Association, Houston, TX Sponsored by NASA
(NASA-CR-187010; NAS 1.26:187010) Avail: NTIS HC/MF A06 CSCL 21/5

The design of a supersonic combustion engine testbed (SCET) aircraft is presented. The hypersonic waverider will utilize both supersonic combustion ramjet (SCRAMjet) and turbofan-ramjet engines. The waverider concept, system integration, electrical power, weight analysis, cockpit, landing skids, and configuration modeling are addressed in the configuration considerations. The subsonic, supersonic and hypersonic aerodynamics are presented along with the aerodynamic stability and landing analysis of the aircraft. The propulsion design considerations include: engine selection, turbofan ramjet inlets, SCRAMjet inlets and the SCRAMjet diffuser. The cooling requirements and system are covered along with the topics of materials and the hydrogen fuel tanks and insulation system. A cost analysis is presented and the appendices include: information about the subsonic wind tunnel test, shock expansion calculations, and an aerodynamic heat flux program. M.G.

N91-10064# Aeronautical Research Labs., Melbourne (Australia).
FLIGHT TESTING OF TWO ALLISON T56 ENGINES MODIFIED TO THE ARL DEVELOPED LOW SMOKE CONFIGURATION
P. N. DOOGOOD Jun. 1990 19 p
(ARL-PROP-TM-449; AR-006-100) Avail: NTIS HC/MF A03

Two Allison T56 engines were modified to the ARL developed low smoke configuration and placed on wing of separate RAAF P-3C Orion aircraft for extensive flight testing. The initial tests are reported and it is concluded that the modification had no adverse effect on the performance of the engine. Author

N91-10065*# Hamilton Standard, Windsor Locks, CT.
MEASUREMENT OF UNSTEADY BLADE SURFACE PRESSURE ON A SINGLE ROTATION LARGE SCALE ADVANCED PROP-FAN WITH ANGULAR AND WAKE INFLOW AT MACH NUMBERS FROM 0.02 TO 0.70 Final Report
P. BUSHNELL, M. GRUBER, and D. PARZYCH Oct. 1988 45 p MF as supplement
(Contract NAS3-23051)
(NASA-CR-182123; E-4137; NAS 1.26:182123) Avail: NTIS HC/MF A03 CSCL 21/5

Unsteady blade surface pressure data for the Large-Scale Advanced Prop-Fan (LAP) blade operation with angular inflow, wake inflow and uniform flow over a range of inflow Mach numbers of 0.02 to 0.70 is provided. The data are presented as Fourier coefficients for the first 35 harmonics of shaft rotational frequency. Also presented is a brief discussion of the unsteady blade response observed at takeoff and cruise conditions with angular and wake inflow. Author

N91-10066# Rolls-Royce Ltd., Derby (England).
AERO ENGINE DESIGN FACTORS FOR A LOW FUEL PRICE SCENARIO
S. J. HARTROPP 15 May 1989 20 p Presented at Canadian Aeronautics and Space Institute, Ottawa, Ontario, 15-17 May 1989
(PNR-90681; ETN-90-97928) Copyright Avail: NTIS HC/MF A03

The driving parameters for aero engine design were reassessed to account for the stabilization of fuel price in the vicinity of 50 cents per gallon. A program embracing studies in the fields of operating cost analysis, reliability research and engine specific thrust effects established principles reflecting the importance of engine direct operating cost. The same factors influence the aircraft life cycle cost, and as legislative compliance, operator acceptance and passenger appeal. The effect of applying these principles to a new powerplant and the ongoing development of current powerplants is evaluated. ESA

N91-10068# Rolls-Royce Ltd., Derby (England).
THE EVOLUTION OF THE BYPASS ENGINE
G. M. LEWIS 27 Oct. 1989 14 p Presented at DGLR Symposium on 50 Years of Jet-Powered Flight, Munich, Fed. Republic of Germany, 26-27 Oct. 1989
(PNR-90707; ETN-90-97939) Copyright Avail: NTIS HC/MF A03

The by-pass principle was understood in the early days of the jet engine. Exploitation of the known concepts progressed as the inherent design problems were solved. The advances which reduced the mechanical design problems of aircraft engines and components are summarized. Engine designs representing significant steps in the evolution of the by-pass engine are identified. ESA

N91-10070# Rolls-Royce Ltd., Bristol (England).
TECHNOLOGY UPDATE OF EARLY GAS TURBINE DESIGNS
ALAN RHODES Derby, England 21 Sep. 1989 12 p Presented at Tactical V/STOL Aircraft Symposium, New Bern, NC, 19-21 Sep. 1989
(PNR-90710; ETN-90-97941) Copyright Avail: NTIS HC/MF A03

The power plant of the Pegasus gas turbine is described. The service hours of Pegasus from 1969 to 1989 in different countries are presented. The design evolution of several modules and subassemblies are shown. The improvements obtained by the total package of changes introduced through the Pegasus update program are summarized. The application of up to date technology to the system provides a cost effective way of bringing to the operator a competitive product. ESA

N91-10071# Rolls-Royce Ltd., Bristol (England).
FUTURE SUPERSONIC TRANSPORT POPULSION OPTIMIZATION
B. W. LOWRIE Derby, England 8 Nov. 1989 8 p Presented ar European Symposium on Future Supersonic/Hypersonic Transport, Strasbourg, France, 8-9 Nov. 1989
(PNR-90737; ETN-90-97950) Copyright Avail: NTIS HC/MF A02

The interest in second generation supersonic transport is considered. The propulsion systems necessary for a commercially and environmentally acceptable aircraft are identified. It is shown that for an isolated installation the tandem fan concept is the best. A feature of most other systems is the increased installation cross section required at a cruise and this causes penalizing levels of ware drag of an isolated system. Typical weight penalities are found to be of less importance than the wave drag. The need to consider integrated rather than isolated installations is emphasized. ESA

N91-10072# Rolls-Royce Ltd., Bristol (England).
APPLICATIONS OF THERMALLY SPRAYED COATING SYSTEMS IN AERO ENGINES
T. N. RHYS-JONES Derby, England 15 Sep. 1989 16 p Presented at 12th International Conference on Thermal Spraying, London, England, 1989
(PNR-90750; ETN-90-97955) Copyright Avail: NTIS HC/MF A03

The principle thermal spray coating process used in aero engine applications are oultlined. Particular attention is given to high velocity combustion and plasma spray techniques. The use of coatings for wear resistance, clearance control, environmental degradation resistance and thermal barrier applications are described. The characteristics of the coatings exhibit a marked dependence on the thermal spray technique itself, the source of materials used and the spray process parameters. ESA

N91-10074# Rolls-Royce Ltd., Derby (England).
HEAT TRANSFER IN AERO ENGINE GAS TURBINES, PART 1
C. T. J. SCRIVENER 15 Jun. 1990 37 p Submitted for publication
(PNR-90754-PT-1; ETN-90-97958) Copyright Avail: NTIS HC/MF A03

Some turbine blade designs, and some important aspects of airfoil internal heat transfer are described. The airfoil external heat transfer is discussed. For the rotor blades of high temperature gas turbines, modern multipass cooling configurations provide efficient effective cooling. They can provide low coolant flow, consistent with this high temperature capability. The heat transfer in airfoil internal passages is well understood. This includes both plain passages, and the characteristics of bends, and enhancement by ribs, pedestals and impingement. The areas where future heat transfer research is required, in order to understand the basic process involved, are summarized. ESA

N91-10075# Rolls-Royce Ltd., Derby (England).
RE-ENGINING: REAL STAGE 3 COMPLIANCE PLUS OTHER BENEFITS
K. GODDARD 6 Apr. 1990 7 p Presented at Avmark Services Ltd. 1990 Update Aircraft Noise Attenuation Conference, 4-6 Apr. 1990
(PNR-90755; ETN-90-97959) Copyright Avail: NTIS HC/MF A02

A study to show that re-engining is the only satisfactory way in converting today's noisy stage 2 airliners to give stage 3 compliance with clear and comfortable margins, together with enhanced performance and improved fuel consumption is presented. The importance of eliminating stage 2 operations for the benefit of the community is summarized. The advantages and driving force behind previous post war re-engining programs are described. ESA

N91-10076# Rolls-Royce, Inc., Atlanta, GA.
DESIGN/DEVELOPMENT ISSUES FOR HIGH BYPASS RATIO FANS
R. R. MORITZ and D. J. NICHOLAS (Rolls-Royce Ltd., Derby, England) Derby, England 15 May 1990 16 p Presented at 37th Annual General Meeting and 2nd Symposium on Propulsion, Toronto, Ontario, 15 May 1990
(PNR-90758; ETN-90-97960) Copyright Avail: NTIS HC/MF A03

Some of the lessons learned in the course of the generation of the RB211 series of engines are presented. The early stages of RB211 development are underlined. Recent experience from present day RB211 program staff is stressed. The RB211 family of engine is compared to other high bypass ratio civil engines. The most obvious differences is in its use of lower aspect ratio fan blades. This feature is credited with a wide range of benefits including better performance, durability and cost of ownership. These and other points are developed. ESA

N91-10927# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
DETERMINATION OF UNSTEADY AERODYNAMIC FORCES ON ENGINES WITH A VIEW TO FLUTTER INVESTIGATIONS [BESTIMMUNG INSTATIONAERER TRIEBWERKSLUFTKRAEFTE FUER DIE ANWENDUNG BEI FLATTERUNTERSUCHUNGEN]
HERMANN TRIEBSTEIN, GUENTER SCHEWE, and HARTMUT ZINGEL (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, Germany, F.R.) *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 141-168 Apr. 1990 In GERMAN; ENGLISH summary
Avail: NTIS HC/MF A13

Experimental investigations of the steady and unsteady aerodynamic forces were performed on an ejector engine model and a wing/engine combination in the subsonic and transonic regimes. The aim was to find out how well the commonly used aerodynamic models for flutter calculations correspond to the actual conditions observed in engines. The comparison of experimental and theoretical results shows that the linear lifting surface theory provides quite accurate unsteady aerodynamic forces. The effects of Mach number and reduced frequency are correctly described. For the wing/engine combination the unsteady interference effect for engine oscillation on the lower side of the wing is strongly influenced by flow separation at the wing/pylon connection. In general, the unsteady aerodynamic forces on the wing are small and, at this order of magitude, can be correctly calculated with the linear lifting surface theory. The interference effect on the oscillating wing on the engine is much more significant. ESA

N91-11018# Stuttgart Univ. (Germany, F.R.). Inst. fuer Luftfahrtantriebe.
TEST LAUNCH FOR TURBOAIRCRAFT ENGINE. DESCRIPTION OF THE INSTALLATION [HOCHENPRUEFSTAND FUER TURBOFLUGTRIEBWERKE. BESCHREIBUNG DER ANLAGE]
1987 23 p In GERMAN
(ILA-87-A-02; ETN-90-97879) Avail: NTIS HC/MF A03

In the framework of aeronautical research, a test bench for

aircraft engine was built. Using different economic principles, such as compact construction, it was possible to build a modern test installation at relatively low cost. The environmental noise problem was particularly studied and solved. ESA

N91-11019# Universitaet der Bundeswehr, Hamburg (Germany, F.R.). Fachbereich Maschinenbau.
INTEGRATION OF MODEL AND KNOWLEDGE BASED DIAGNOSIS, WITH THE EXAMPLE OF A TURBOJET ENGINE Ph.D. Thesis [INTEGRATION VON MODELLBEZOGENER UND WISSENSBASIERTER DIAGNOSE AM BEISPIEL EINES TURBOFLUGTRIEBWERKES]
UWE WILLAN 1990 169 p In GERMAN Sponsored by Bundesministerium der Verteidigung
(ETN-90-97900) Avail: NTIS HC/MF A08

The early detection of failures in technical processes in general, and in aircraft engines in particular is of great importance. Besides the precise statement of place and size of a failure already apparent (diagnosis), it is also of interest to predict its occurrence (prediction). The aim of this investigation is to utilize for an actual project, various processes which are able to fulfill these tasks. The point is the possible utilization of a microcomputer. Two basic principles are carried out, the model based diagnosis and the knowledge based diagnosis. The two systems are presented with some criteria for the choice of the system more adapted for use in precise actual cases. A work developed in this connection for an aircraft engine has led to the production of largely automatized model which is valid for any gas turbine. The design of an expert system for the diagnosis of the part of an aircraft which cannot be modeled, is stated. Various processes suitable for connecting together both types of diagnosis are presented and discussed. The resulting integrated system unites the advantages of both methods, not taking into account their drawbacks. ESA

N91-11022# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Panel.
TEST CASES FOR COMPUTATION OF INTERNAL FLOWS IN AERO ENGINE COMPONENTS
LEONHARD FOTTNER, ed. (Universitaet der Bundeswehr Muenchen, Neubiberg, Germany, F.R.) Jul. 1990 393 p
(AGARD-AR-275; ISBN-92-835-0573-5) Copyright Avail: NTIS HC/MF A17; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

An analytical and experimental data base intended as support in the development of new and the refinement of existing codes for computing internal flows in aero engine components, specifically in cascades, compressors, turbines and ducts ahead of and between them is presented. All the analytical test cases described are relevant to steady, 2-dimensional, inviscid flow calculations. The experimental test cases are relevant to steady 2-dimensional, quasi- or fully 3-dimensional flow calculations for viscous flows in axial turbomachinery components. These data are believed to represent the highest quality analytical and experimental test cases available today. However, in appraising the large amount of experimental data submitted, the Working Group necessarily had to consider what the requirements for a satisfactory test case are and what experimental precautions and problems have to be addressed and overcome. It also became apparent where gaps exist in the available test cases and what is required for the future. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A91-10955
ALL-ELECTRIC FLIGHT CONTROL EXPERIMENTS AND EXPERIMENTS WITH A SIDESTICK ON THE CONCORDE [EXPERIMENTATION SUR CONCORDE D'UN SYSTEME DE COMMANDES DE VOL TOUT ELECTRIQUE ET D'UN MINI-MANCHE]
Y. NEGRE (Aerospatiale, Toulouse, France) and G. CORMERY IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 53-57. In French.
Copyright

The framework in which experiments were made on the supersonic Concorde aircraft to study electrical digital flight controls required to overcome longitudinal instability is presented. Installation of a sidestick to replace normal wheel and stick commands also became part of this study. Ergonometric evaluations were carried out to achieve an optimum configuration of the sidestick from the pilot-aircraft symbiotic viewpoint. This experimental system also considered active control of wing aerodynamic loads, the control of wing camber, and the increase in flutter speeds. Two flight control principles evolved from these tests: (1) the stick load in pitch should be constant throughout the flight envelope, and (2) the load applied to the stick to give a given roll rate should be roughly constant throughout the flight envelope. R.E.P.

A91-11155
PERFORMANCE-ROBUSTNESS TRADE OFF OF EIGENSTRUCTURE ASSIGNMENT APPLIED TO ROTORCRAFT
M. INNOCENTI and C. STANZIOLA (Pisa, Universita, Italy) Aeronautical Journal (ISSN 0001-9240), vol. 94, April 1990, p. 124-131. refs
Copyright

The eigenstructure assignment (EA) method, used in the past for synthesis of helicopter flight control systems in the time domain, is discussed, and its properties are compared with the standard linear quadratic regulator (LQR) method in order to define a loop transfer recovery procedure similar to that of the LQG/LTR. The EA method is considered simpler, since it offers a trial and error procedure, in which the closed loop system is expressed by the shape of the system's response, but the method does not guarantee the stability margins. The LQR method uses a functional minimization procedure, requiring long iterations, but it guarantees the stability margins. Synthesis by both methods is compared for two applications. The two systems show similar results in terms of robustness. It is concluded that the EA method, although it is not capable of guaranteeing minimum stability margins, may still play an important role in flight control system analysis when robustness issues are of major concern. B.P.

A91-11158
PILOT MODELLING TECHNIQUES FOR THE ANALYSIS OF AIRCRAFT LINEAR DYNAMIC BEHAVIOUR
M. INNOCENTI (Auburn University, AL) and R. L. MINCIOTTI (Pisa, Universita, Italy) Aeronautical Journal (ISSN 0001-9240), vol. 94, May 1990, p. 153-164. Research sponsored by CNR. refs
Copyright

The evaluation of aircraft flying qualities has always required a high level of integration between aircraft dynamic response and human operator properties. Today, the linear pilot-aircraft behavior is a mature technology summarized by the publication of the military specifications MIL-STD-1797. The present paper outlines the contribution of pilot modeling techniques to such endeavor and their use as a tool in the prediction of aircraft handling qualities

characteristics by verifying their output in a Neal-Smith criterion framework. The objective is to complete the understanding of handling qualities in the linear part of the flight envelope (such as tracking) and to initiate work in the large amplitude maneuvers. The results have produced an interactive computer-aided software useful for pilot-in-the-loop analysis. Author

A91-11820
MATHEMATICAL MODELLING FOR ANALYSIS OF NONLINEAR AIRCRAFT DYNAMICS
A. L. GONZALEZ BLAZQUEZ (ESA, Paris, France) (George Washington University, University of Virginia, and NASA, Symposium on Computational Technology for Flight Vehicles, Washington, DC, Nov. 5-7, 1990) Computers and Structures (ISSN 0045-7949), vol. 37, no. 2, 1990, p. 193-197. refs
Copyright

A model for the analysis of the nonlinear motion of a swept-wing aircraft at high angles of attack is presented. The most difficult part of the mathematical formulation and the main source of the highly nonlinear motion is the aerodynamic behavior of the aircraft. In order to understand it, the basic aerodynamic phenomena of delta- and swept-wing aircraft are reviewed, deriving the main aspects affecting the motion dynamics. Aerodynamic data obtained from wind-tunnel tests have been analyzed and used to obtain the force and moment modeling. A general formulation of the dynamic equations valid for high angles of attack and sideslip is presented. Author

A91-12928#
DESIGN TECHNOLOGIES UTILIZED IN THE DEVELOPMENT OF THE B-2 FLIGHT CONTROL SYSTEM
J. F. MOYNES (Northrop Corp., B-2 Div., Pico Rivera, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems, and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 10 p.
(AIAA PAPER 90-3254) Copyright

This paper presents an overview of the holistic issues involved in developing a flight control system for a high performance, relaxed static stability, stealth aircraft such as the B-2. The paper touches on the conflicts and trades which are presented by low observables, performance, mission requirements, structural loads and dynamics, ride quality, and stability and control. For purposes of illustration a design example is presented addressing how the principal stability feedbacks were chosen and how they influenced the flight control system architecture. Author

A91-12929#
THE DESIGN APPROACH USED IN THE SYNTHESIS OF THE B-2 LATERAL-DIRECTIONAL CONTROL LAWS
P. W. SAUNDERS and D. A. HAGEMEYER (Northrop Corp., B-2 Div., Pico Rivera, CA) AIAA, AHS, and ASEE, Aircraft Design, Systems, and Operations Conference, Dayton, OH, Sept. 17-19, 1990. 11 p.
(AIAA PAPER 90-3255) Copyright

The B-2 bomber mission requirements dictated revolutionary changes in the aircraft's configuration which led to the rebirth of the earlier Northrop all-wing design concept. Inherent in the application of all-wing aircraft are some fundamental lateral-directional controllability problems due to the lack of vertical surfaces. To address these problems, modern control theory was applied to define a stability-augmentation system that would operate in a highly reliable fly-by-wire flight-control system. This has led to significant improvements in the flying qualities and utility of the flying wing, as is evident in the early flight test results of the B-2. Author

N91-10077 National Aerospace Lab., Tokyo (Japan). STOL Aircraft Project Group.
THE FULL-BODY GROUND VIBRATION TESTS USING THE LOW-NOISE STOL TEST PLANE [TEISOUON SUTORU JIKKENKI NO ZENKI CHIJOU SHINDOU SHIKEN (SHINDOU DETA KANRISHISUTEMU)]
Oct. 1987 30 p In JAPANESE
(NAL-TM-576; ISSN-0452-2982; JTN-90-80005) Avail: NTIS HC/MF A03

Experimental oscillation test equipment of NAL (National Aerospace Laboratory) was used for the whole-craft terrestrial oscillation test of the low-noise experimental STOL craft. The main components of the equipment include a system for analyzing multi-point applied oscillation, an oscillation data control system and a model analyzer. An oscillation test of the actual craft will need the exchange between several large scale or personal computers of the data obtained in the oscillation analyses and the experimental oscillation test. The oscillation control system assures the interexchange of data between different data types and the conversion of information media. This report presents the configuration and funtions of the system for analyzing multi-point applied oscillation and describes the role of the oscillation data control system in the whole-craft oscillation test. The report also described the developed software and its actual applications. NASDA

N91-10078*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DETERMINATION OF THE PRESSURE DRAG OF AIRFOILS BY INTEGRATION OF SURFACE PRESSURES
WILLIAM H. PHILLIPS Oct. 1990 26 p
(NASA-TM-102722; NAS 1.15:102722) Avail: NTIS HC/MF A03 CSCL 01/3

A study was conducted of the causes of pressure drag of subsonic airfoils. In a previous paper by the author, the pressure drag is obtained by calculating the total drag from the momentum defect in the boundary layer at the trailing edge and subtracting the friction drag obtained from integration of surface friction along the chord. Herein, the pressure drag is obtained by integrating the streamwise components of surface pressure around the airfoil. Studies were made to verify the accuracy of the integration procedure. The values of pressure drag were much smaller than those obtained by the previous method. This lack of agreement is attributed to the difficulty of calculating boundary layer conditions in the vicinity of the trailing edge and to the extreme sensitivity of the circulation and lift to the trailing edge conditions. The results of these studies are compared with those of previous investigations. Author

N91-10079*# National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
FLIGHT CHARACTERISTICS OF A MODIFIED SCHWEIZER SGS1-36 SAILPLANE AT LOW AND VERY HIGH ANGLES OF ATTACK
ALEX G. SIM Jul. 1990 48 p
(NASA-TP-3022; H-1563; NAS 1.60:3022) Avail: NTIS HC/MF A03 CSCL 01/3

A manned flight research program using a modified sailplane was conducted to very high angles of attack at the NASA-Ames. Piloting techniques were established that enabled the pilot to attain and stabilize on an angle of attack in the 30 to 72 deg range. Aerodynamic derivatives were estimated from the flight data for both low and very high angles of attack and are compared to wind tunnel data. In addition, limited performance and trim data are presented. Author

N91-11023 Oklahoma State Univ., Stillwater.
A NEW APPROACH TO THE FLIGHT CONTROL SYSTEM RECONFIGURATION FOLLOWING A BATTLE DAMAGE AND/OR GENERIC FAILURE ON A CONTROL SURFACE Ph.D. Thesis
MARCELLO ROSARIO NAPOLITANO 1989 200 p
Avail: Univ. Microfilms Order No. DA9019502

Battle damages and/or generic failures are the cause of many accidents involving the loss of aircraft. Particular approaches for three tasks of the overall flight control system reconfiguration problem are considered. These tasks are: damaged model estimation, reconfiguration law design and feedback structure redesign. First, the estimated model of the damaged aircraft is obtained by using a multiple model Kalman filtering approach.

Then, a particular algorithm is applied to the flight control reconfiguration. The determination of the desired control law, which can adapt in a very short period of time to a major damage on a main control surface, is obtained by making use of the recent control and response time histories. Furthermore, a particular approach is proposed in order to calculate a new set of feedback gains of the flight control system such that dynamic uncoupling and desirable handling qualities are retained even after the damage. The model estimation, the control algorithm, and the feedback gains updating process were codified in computer simulation programs for a 6 degrees of freedom aircraft model. The simulation results of the reconfiguration are presented. Dissert. Abstr.

N91-11024 Oxford Univ. (England).
H INFINITY-DESIGN AND THE IMPROVEMENT OF HELICOPTER HANDLING QUALITIES Ph.D. Thesis
ANDREW YUE 1988 245 p
Avail: Univ. Microfilms Order No. BRD-89468

The results of a study into the use of H(infinity)-optimization for the design of feedback control laws for improving the handling qualities of a Lynx helicopter are presented. An important improvement to the H(infinity)-optimization procedure is the reduction in the number of iterative steps in the gamma iteration before convergence to the optimal gamma. Some new algorithms are derived which significantly reduce the computation time for the gamma iteration. Both 2-block and 4-block cases are considered. Control laws are designed for precise control of pitch and roll attitude, yaw rate and heave velocity. Analysis of the raw helicopter showed the need for a stability augmentation system as the dynamic characteristics of the unaugmented helicopter do not comply with military helicopter handling qualities requirements. Results from current research on helicopter handling qualities were used as guidelines in order to define the required dynamic characteristics. A six-degree of freedom nonlinear simulation was used to analyze the helicopter dynamic time histories. A possible solution to the problem of incorporating helicopter handling qualities in the design of robust controllers is to use a two-degree of freedom controller structure. This is illustrated using both H2 and H(infinity)-optimization. A piloted simulation study to assess the effectiveness of advanced control laws was initiated at the Royal Aerospace Establishment (RAE), Bedford. The trials were carried out in the single seat cockpit flight simulator, at the Flight Research Division and represent the first ever real-time piloted simulation using a H(infinity)-controller. Dissert. Abstr.

N91-11025# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Aircraft Div.
REVIEW OF ACTIVE STRUCTURAL CONTROL SYSTEMS AND FLIGHT TEST TECHNIQUES FOR DYNAMIC STABILITY INVESTIGATIONS
OTTO SENSBURG Apr. 1989 36 p Presented at Gabriel Coupry Memorial Lecture
(MBB/FYT256/S/PUB/361/A; ETN-90-97845) Copyright Avail: NTIS HC/MF A03

The influence of G. Coupry on aerolastics with focus on his studies of dynamic response to atmospheric turbulence with the introduction of a non cyclindrical gust, gust alleviation with an open loop flight control system, and vibration testing by transient excitation for application to flight flutter tests is reported. His work on dynamic response to atmospheric turbulence proved that for modern transport airplanes a non cyclindrical gust must be used to achieve a weight optional design. The methods he developed for identification of dynamic stability parameters finally led to the way to an integrated flight test procedure. ESA

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RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A91-11758#
COMPARISON OF AFTERBODY TEST SETUPS FOR COMBAT AIRCRAFT MODEL
M. HUGOUVIEUX, M. LYONNET, and J. P. LEDY (Supersonic Tunnel Association, Semi-annual Meeting, 73rd, Urbana, IL, Mar. 26, 27, 1990) ONERA, TP no. 1990-70, 1990, 8 p.
(ONERA, TP NO. 1990-70)

The process of defining test setups for the S2MA wind tunnel to compare twin-engine combat aircraft afterbody drag for shape optimization purposes is studied. The propulsion system is simulated by compressed-air jets. Preliminary research consisted of afterbody pressure measurement, local weighing of the afterbody, and global weighing of the model and support assembly in order to determine the drag coefficient. Two types of model setup systems were considered. To validate the useful Mach range of these measuring techniques with each of the two setups, preliminary tests in the S3MA wind tunnel were conducted with a model-support system half the scale of the one planned for S2MA. Results of the S3MA are given and the S2MA qualification tests are described. Drag differences of 0.0002 on afterbody shapes of combat aircraft with jet engine simulation were measured. L.K.S.

A91-11760#
THE CEPRA 19 ANECHOIC WIND TUNNEL [LA SOUFFLERIE ANECHOIQUE CEPRA 19]
G. FOURNIER (ONERA, Chatillon, France) (Groupe Franco-Sovietique, Sous-Groupe de Aerodynamique-Structure-Acoustique, Reunion, Chatillon, France, June 25-27, 1990) ONERA, TP no. 1990-72, 1990, 15 p. In French.
(ONERA, TP NO. 1990-72)

A review of the development and recent additions and refinements to the CEPRA 19 anechoic wind tunnel are presented. Airflow speeds of 100 m/s are attained in the 2-m-diameter section and 50 m/s in the 3-m section. The turbulence and acoustic disturbance levels are very low. The principal tests have been made on the noise of helicopter rotors and jet engine exhausts. The characteristics of this wind tunnel are described, and some sample test results are presented. R.E.P.

A91-11766#
S4MA HYPERSONIC FACILITY - FLOW ANGULARITIES MEASUREMENTS IN THE S4MA WIND TUNNEL
M. GRANDJACQUES (ONERA, Modane, France) (Supersonic Tunnel Association, Semi-annual Meeting, 73rd, Urbana, IL, Mar. 26, 27, 1990) ONERA, TP no. 1990-85, 1990, 16 p.
(ONERA, TP NO. 1990-85)

In order to gain better knowledge about the Mach 6.4 nozzle of the Hermes spaceplane, flow angularities measurements were conducted in the S4MA hypersonic wind tunnel of ONERA, in April 1989. The test was done in three parts by means of five-holed hemispherical probes mounted on a rake. The first part consisted of calibrating the probes. Probe coefficients of sensitivity to the flow direction were determined by varying the rake angle of attack and sideslip. Manufacturing defects in the probe were also determined by rotating them 180 deg on axis. During the second part of the test, clinometric probing of the test section was conducted. The same probe rake was mounted on a device allowing it to be moved longitudinally in the jet without varying the probe direction. The tests produced coherent results and showed flow convergence toward the nozzle axis in the sound core, with angularities of approximately 0.5 deg at the edge and decreasing on the vanishing axis. L.K.S.

A91-12536*# *National Aeronautics and Space Administration.* Langley Research Center, Hampton, VA.
THE DESIGN OF TWO SONIC BOOM WIND TUNNEL MODELS FROM CONCEPTUAL AIRCRAFT WHICH CRUISE AT MACH NUMBERS OF 2.0 AND 3.0
ROBERT J. MACK (NASA, Langley Research Center, Hampton, VA) and KATHY E. NEEDLEMAN (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(AIAA PAPER 90-4026) Copyright

A method for designing wind tunnel models of conceptual, low-boom, supersonic cruise aircraft is presented. Also included is a review of the procedures used to design the conceptual low-boom aircraft. In the discussion, problems unique to, and encountered during, the design of both the conceptual aircraft and the wind tunnel models are outlined. The sensitivity of low-boom characteristics in the aircraft design to control the volume and lift equivalent area distributions was emphasized. Solutions to these problems are reported; especially the two which led to the design of the wind tunnel model support stings. Author

A91-12724
APPLICATION OF CRYOGENIC WIND TUNNEL WITH LIQUID NITROGEN AND SELECTION OF ITS TEMPERATURE LEVEL
GUANG-HUA JI (Xian Jiaotong University, People's Republic of China) (International Cryogenic Engineering Committee, International Institute of Refrigeration, Chinese Association of Refrigeration, et al., International Cryogenic Engineering Conference, 13th, Beijing, People's Republic of China, Apr. 24-27, 1990) Cryogenics, Supplement (ISSN 0011-2275), vol. 30, Sept. 1990, p. 183-186. refs
Copyright

An account is given of the essential features and advantages of cryogenic wind tunnels, which allow the testing of models at full scale Reynolds numbers as well as the appropriate Mach numbers. Attention is given to the design and results of a cryogenic wind tunnel operational characterization experiment involving the effects of nitrogen vapor condensation, which degrades the degree of analogous behavior between the cryogenic fluid employed and atmospheric air. The experimental results obtained establish that the lower limit of cryogenic fluid temperatures must be the homogeneous condensation temperature of nitrogen. O.C.

A91-12890#
RESIDUAL INTERFERENCE AND WIND-TUNNEL WALL ADAPTATION
M. MOKRY (National Research Council of Canada, High Speed Aerodynamics Laboratory, Ottawa) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1772-1781. Previously cited in issue 09, p. 1294, Accession no. A89-25130. refs
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N91-10080 National Aerospace Lab., Tokyo (Japan).
CONFIGURATION, FUNCTION AND PERFORMANCE OF THE FLIGHT SIMULATION TEST FACILITY AND ITS MOTION SIMULATION SYSTEM [HIKOU SHIMYURESHON SHIKEN SETSUBI MOSHON MOGI SOUCHI NO KOUSEI OYOBI KINOUSEINOU]
HIROYASU KAWAHARA, MASANORI OKABE, AKIRA WATANABE, TOSHIO BANDO, and KAORU WAKAIRO Jun. 1987 38 p In JAPANESE
(NAL-TM-575; ISSN-0452-2982; JTN-90-80004) Avail: NTIS HC/MF A03

The National Aerospace Laboratory (NAL) has fixed the simulation control unit, the visual simulation unit and the motion simulation unit over a period of three years and four months since 1980. The present report explains the configuration, function, and capacity of the motion simulation unit. For multi-freedom-degree motion simulation units, various kinds of systems have been developed and are in use such as Zimbal method, joint-motion suspension method, joint-motion support method, and special drive method. The joint-motion six-freedom-degree support method was adopted. NASDA

N91-10082 *National Aerospace Lab., Tokyo (Japan).*
FUNCTION AND PERFORMANCE OF VISUAL SIMULATION UNIT OF FLIGHT SIMULATION TEST FACILITY
KAORU WAKAIRO, HIROYASU KAWAHARA, AKIRA WATANABE, and MASANORI OKABE Feb. 1988 28 p In JAPANESE
(NAL-TM-581; ISSN-0452-2982; JTN-90-80009) Avail: NTIS HC/MF A03

The visual simulation unit with CGI (Computer Generated Imagery) enables a simulation of natural conditions by obtaining a wide view thanks to an increase in the number of display channels which catch sight of a wider range of flight. It is characterized by the ability to indicate an object in motion within sight as well as to add, delete, change, or otherwise revise the configuration of the ground or buildings generated as a simulated vision. The configuration, function, and capacity of the visual simulation unit with the CGI was introduced in consideration of the necessity to cope with a simulation test intended for the research and development of a new aircraft model including STOL at the National Aerospace Laboratory (NAL). Attention was paid in the designing of the unit to the ease of preparation of a three-dimensional visual model, the ability to simulate a daytime sight in color and nighttime lights of various kinds, the ability to easily simulate natural conditions and the ease of maintenance. NASDA

N91-10083*# Nevada Univ., Reno. Engineering Research and Development Center.
NUMERICAL INVESTIGATIONS IN THREE-DIMENSIONAL INTERNAL FLOWS Semiannual Status Report, 1 Jan. - 30 Jun. 1990
WILLIAM C. ROSE 11 Sep. 1990 29 p
(Contract NCC2-507)
(NASA-CR-186958; NAS 1.26:186958) Avail: NTIS HC/MF A03
CSCL 14/2

The flow in the transonic test facility was investigated using the three dimensional computational fluid dynamics techniques. The application of the full Navier-Stokes three dimensional code to the flow qualities in the contraction section of transonic wind tunnel is discussed. Initially, two dimensional solutions indicated the possibility for large secondary flow to exist as a result of the asymmetries involved in the contraction section as it is constructed. The results of a full three dimensional solution indicate that only minor pressure variations actually occur in the contraction section within any given cross flow plane. Further analysis of the three dimensional solution indicated that these slight lateral pressure gradients lead to negligible secondary flows, except within a small region in the corners within the boundary layer. On the basis of present solution, it would not be expected that any flow asymmetries and/or secondary flow present within contraction section are associated with the methods by which the contraction is implemented in its present configuration. Author

N91-10084# Federal Aviation Administration, Atlantic City, NJ.
FAA AIR TRAFFIC OPERATIONAL EVALUATION OF AUTOMATED SURFACE OBSERVING SYSTEM (ASOS)
ELIZABETH TURCICH and BRUCE E. WARE Oct. 1990 35 p
(DOT/FAA/CT-TN90/42) Avail: NTIS HC/MF A03

The results of the Federal Aviation Administration (FAA) Air Traffic Operational Evaluation of Automated Surface Observing System (ASOS) at the Tulsa International Airport, Oklahoma are detailed. The evaluation was conducted in order to obtain operational air traffic controller reaction to the AAI Corporation preproduction ASOS. The evaluation resulted in numerous recommendations to improve the ASOS prior to production.
Author

N91-10086# Institut Franco-Allemand de Recherches, Saint-Louis (France).
THE ISL HYPERSONIC SHOCK TUNNEL AND ITS INSTRUMENTATION
G. SMEETS 1 Jun. 1989 22 p Presented at VKI (AGARD Ad-Hoc Study Group on Hypersonic Technology-Subgroup on Hypersonic Wind Tunnel Instrumentation) Conference, 16 May

1989
(ISL-CO-213/89; ETN-90-97572) Avail: NTIS HC/MF A03

Th ISL hypersonic shock tunnel is described and the characteristics of hypersonic flows which can be produced in the shock tunnel are given. The five essential measuring techniques developed or collected during the last three decades when operating the tunnel, are presented: differential interferometry for flow vizualization and/or quantitative flow density measurements; laser differential interferometry for precise measurements of optical paths in a low density gas medium; heat flux measurements with thin film resistance thermometers; laser Doppler velocimetry; and the measurement of aerodynamic forces and moments in milliseconds. ESA

N91-10925# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
DESIGN OF THE DERIVATIVE BALANCE FOR THE TRANSONIC WIND TUNNEL [KONSTRUKTIVE AUSLEGUNG DER TRANSKANAL-DERIVATIVAWAAGE (TRAD)]
EBERHARD SCHMIDT and JOACHIM WAGENER *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 105-125 Apr. 1990 In GERMAN; ENGLISH summary
Avail: NTIS HC/MF A13

The design of a dynamic derivative balance for a transonic wind tunnel is presented. Several technical problems had to be overcome to obtain, despite the extremely high model loads (normal force of 2800 N at an angle of attack of 32 deg), oscillatory model motions with constant amplitudes, while limiting the rig diameter within the model to that of a conventional strain gauge force balance. The final construction of the five component balance, the spring element bearings for pitch and roll oscillations, and the forcing mechanisms for the sinusoidal motions using a stepping motor drive are described. These technical details may be useful for the design of other dynamic test installations or special industrial machinery. ESA

N91-10928# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
UNSTEADY WIND TUNNEL WALL INTERFERENCES IN SUBSONIC AND TRANSONIC PROFILE FLOWS [INSTATIONAERE WINDKANALWAND-INTERFERENZEN BEI SUB- UND TRANSSONISCHER PROFILUMSTROEMUNG]
RALPH VOSS *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 169-185 Apr. 1990 In GERMAN; ENGLISH summary
Avail: NTIS HC/MF A13

Unsteady wind tunnel wall interference effects in subsonic and transonic flows about oscillating 2-D airfoils were theoretically investigated using a panel method and a finite difference time marching method. The results show strong effects on magnitude and phase of unsteady pressure and lift coefficients. Transonic interference effects are even stronger than the well known subsonic ones. Tunnel resonance appears in subsonic and transonic flows for the same flow parameters. Based on the subsonic panel method transonic measurements can be approximately corrected for unsteady interference effects, if pressure distributions at the walls are known. ESA

N91-10975# Technische Univ., Brunswick (Germany, F.R.). Inst. of Flight Guidance and Control.
WIND MODELS FOR FLIGHT SIMULATION
K.-U. HAHN, T. HEINTSCH, B. KAUFMANN, G. SCHAENZER, and M. SWOLINSKY *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 1. Part 1: Fundamentals. Part 2: Flight in Critical Atmospheric Conditions. Part 3: Impact of New On-Board Technologies on Aircraft Operation 32 p Mar. 1990 Sponsored by DFG
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Wind shear, downdraft, and turbulence can endanger takeoff and landing approach. The effects of wind results in a modified dynamic response of the aircraft as well as in flight performance variation. In each case flight path deviation can occur, more or less controlled by the pilot. For the analysis of the aircraft behavior in a changing wind field, a mathematical model of the aircraft is used including the wind effects. It can be said, that gusts and turbulence will have more influence on the pilot workload and reaction to this short scale wind disturbances. Large scale wind variations can produce significant flight path safety problems. An important aspect for the flight safety is the energy situation of an aircraft affected by wind. Therefore this was chosen as a useful criterion for the determination of the influences of the wind and wind variation. Author

N91-11026# National Aerospace Lab., Tokyo (Japan).
FLIGHT SIMULATOR EVALUATION TEST OF MULTI-FUNCTIONAL DISPLAY UNIT [TAKINO HYOJI SOCHI NO HIKO SHIMYURE-SHON HYOKASHIKEN]
HIROYASU KAWAHARA, AKIRA WATANABE, KAORU WAKAIRO, and KEIJI TANAKA Oct. 1988 34 p In JAPANESE
(NAL-TM-596; ISSN-0452-2982; JTN-90-80122) Avail: NTIS HC/MF A03

As a part of the design of the new cockpit, in order to make clear the efficiency and the technical feasibility of the cathode ray tube-type display system, the simulation test for both the headdown display system and the digital map display system was made to evaluate results. The evaluation test was made using the multi-purpose flight simulator of the National Aerospace Laboratory in Japan. As a result, some items which need to be improved for the headdown display unit were suggested. They are as follows: (1) the improvement of the scale of the bank angle and the bank pointer, (2) the improvement of the display of digits on the magnified digital display, (3) the improvement of the magnified display of velocity, (4) the change of the shape of both the glide slope and the pointer localizer, (5) to keep the stability of a color tone on brightness regulation function, and (6) to study the edge-smoothing technique. For the digital map display system, the following items needed for improvement were suggested: (1) introduction of the scale-up and -down function, (2) moving down the symbol of an airplane itself from the center of a display, (3) to make colors of each displayed item recognizable, (4) to display the higher mountain and obstacles by using warning colors and to make one pay attention to them by using flickering light, (5) to use a three dimensional display technique, and (6) to improve the resolution of it by increasing scanning lines. NASDA

N91-11027*# Physical Sciences, Inc., Andover, MA.
PROPULSION SIMULATION FOR MAGNETICALLY SUSPENDED WIND TUNNEL MODELS Final Report, Jan.-Sep. 1988
PRAKASH B. JOSHI, HENRY P. BEERMAN, JAMES CHEN, ROBERT H. KRECH, ANDREW L. LINTZ, and DAVID I. ROSEN Oct. 1990 73 p
(Contract NAS1-18616)
(NASA-CR-182093; NAS 1.26:182093; PSI-2055/TR-859) Avail: NTIS HC/MF A04 CSCL 14/2

The feasibility of simulating propulsion-induced aerodynamic effects on scaled aircraft models in wind tunnels employing Magnetic Suspension and Balance Systems. The investigation concerned itself with techniques of generating exhaust jets of appropriate characteristics. The objectives were to: (1) define thrust and mass flow requirements of jets; (2) evaluate techniques for generating propulsive gas within volume limitations imposed by magnetically-suspended models; (3) conduct simple diagnostic experiments for techniques involving new concepts; and (4) recommend experiments for demonstration of propulsion simulation techniques. Various techniques of generating exhaust jets of appropriate characteristics were evaluated on scaled aircraft models in wind tunnels with MSBS. Four concepts of remotely-operated propulsion simulators were examined. Three conceptual designs involving innovative adaptation of convenient technologies (compressed gas cylinders, liquid, and solid propellants) were developed. The fourth innovative concept,

namely, the laser-assisted thruster, which can potentially simulate both inlet and exhaust flows, was found to require very high power levels for small thrust levels. Author

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A91-10972
SYSTEM OPTIMIZATION STRUCTURE AND PROPULSION OF A HYPERSONIC SPACE TRANSPORTATION SYSTEM (SAENGER)
DIETRICH E. KOELLE (MBB GmbH, Ottobrunn, Federal Republic of Germany) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, *Proceedings. Toulouse, France, Cepadues-Editions*, 1990, p. 257-262. refs
Copyright

The paper presents the design status of the Saenger launch vehicle concept, which comprises a hypersonic aircraft-type first stage with turboramjet propulsion. The vehicle is conceived for Mach 4.4 cruise speed (28 km altitude) and Mach 6.6 stage separation velocity in 37 km altitude. Aerodynamical, thermal, structural and propulsion design features are discussed as they have evolved after 3 years of study work. Author

A91-10973
HYPERSONIC SPACE TRANSPORT SYSTEM - CRUISER OR ACCELERATOR?
J. M. ROUBERTIE and M. RIGAULT (AMDBA, S.A., Saint-Cloud, France) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 264-267. refs
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Some considerations on airbreathing launchers are presented and similarities, differences, and potential synergies with hypersonic commercial transport aircraft are discussed. A hypersonic transport aircraft is essentially a cruiser as acceleration and deceleration are a relatively small portion of the flight. It is shown that strong commonality between a hypersonic passenger aircraft and an airbreathing launcher is not likely, but the analogies are enough to justify a synergy in the feasibility and development phases (Rigault, 1989) due to common technological requirements. The material development effort should have some common needs. Other areas in the fields of aerodynamics, cryogenic fuel storage and management, and propulsion may also rely on similar developments. Common test facilities may also be used for all these technologies. R.E.P.

A91-10974
BASIC MATERIALS AND STRUCTURES ASPECTS FOR HYPERSONIC TRANSPORT VEHICLES (HTV)
E. STEINHEIL and W. UHSE (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 269-275.
Copyright

A Mach 5 transport design is used to illustrate structural concepts and criteria for materials selections and also key technologies that must be followed in the areas of computational methods, materials and construction methods. Aside from the primary criteria of low weight, low costs, and conceivable risks, a number of additional requirements must be met, including stiffness and strength, corrosion resistance, durability, and a construction adequate for inspection, maintenance and repair. Current aircraft construction requirements are significantly extended for hypersonic vehicles. Additional consideration is given to long-duration temperature resistance of the airframe structure, the integration of large-volume cryogenic fuel tanks, computational tools, structural design, polymer matrix composites, and advanced manufacturing technologies. R.E.P.

A91-10977* National Aeronautics and Space Administration. Hugh L. Dryden Flight Research Facility, Edwards, CA.
THE NEED FOR A HYPERSONIC DEMONSTRATOR
T. G. AYERS (NASA, Flight Research Center, Edwards, CA) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 290-296.
Copyright

The requirement for research aircraft and demonstrator vehicles has been seriously challenged by tight budgets and erroneous impressions that aeronautical technology has matured to a point where the value added by flight research and/or demonstration is not sufficient to offset the costs. While this issue may be debatable with respect to subsonic/transonic speeds, such is not the case for high-speed (supersonic and hypersonic) operation. The aerodynamic performance, weight/payload fractions, and thermodynamic problems are such that small margins of error can be tantamount to the vehicle being unable to reach its design point or so inefficient as to render it useless. This paper addresses some of the critical design considerations and operational constraints which make it mandatory to carry out flight research and develop a demonstrator vehicle in order that the risks be reduced to an acceptable level to assure technology readiness for viable hypersonic flight. Author

A91-10978
THE CASE OF A HYPERSONIC FLIGHT DEMONSTRATOR
W. B. HERBST and P. SACHER (MBB GmbH, Munich, Federal Republic of Germany) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 298-300.
Copyright

A new high speed research vehicle is planned to be developed and flight tested which would explore the flight regime up to M = 6 and which would be powered by an airbreathing turbo-ram propulsion system. It would form the technological basis for the lower stage of a future two-stage spaceplane. The paper is taking reference to historical and current experimental aircraft and outlines the engineering challenge of designing a hypersonic research vehicle. Author

A91-11737
SOVIET SPACE PLANES
DENNIS NEWKIRK Spaceflight (ISSN 0038-6340), vol. 32, Oct. 1990, p. 350-355. refs
Copyright

The development history of the Soviet shuttle-type spacecraft which led to the development and November 1988 launch of the Buran orbiter is reviewed. It is pointed out that new evidence indicates that early Soviet plans to develop such a craft in the 1960s were of greater magnitude than similar plans proposed in the U.S. It is noted that both countries can trace their shuttle development back to German studies of the Antipodal Bomber. Soviet developments are seen as a response to similar developments in the U.S., with the U.S. Dyna-Soar program apparently prompting the Soviet Project 50/50 which produced designs for the 8 x 7.4 x 3.5-m 10,3000-kg folded-wing spacecraft Lapot. The continued work on the Lapot from 1974-79 is recounted, and its contribution to the BOR-4 program (1982-1984) is detailed. The known flight history of BOR-4, beginning with the Cosmos 1374 launched on June 3, 1982 from Kapustin Yar by an SL-8 booster, is reviewed. L.K.S.

N91-11035# National Aerospace Lab., Tokyo (Japan). Control Systems Div.
FLIGHT SIMULATION PROGRAMS FOR SPACE PLANE [UCHU OKANKI HIKO SHIMYURE-SHON PUROGURAMU]
MASAAKI YANAGIHARA Aug. 1988 45 p In JAPANESE (NAL-TM-594; ISSN-0452-2982; JTN-90-80120) Avail: NTIS HC/MF A03

A flight simulation program that could simulate the flight of an spaceplane from the ground surface to the orbit around the earth was developed. This program is the advanced version of the general purpose program for the flight simulation which has been developed in the National Aerospace Laboratory of Japan. Two programs are available to analyze the rigid body motion with six degrees of freedom or the mass point motion with three degrees of freedom. They are written in FORTRAN. The merits and limitations of the program are as follows: (1) it is composed of two package programs, that is, fuselage models and onboard calculations (these packages are replaceable and thus the program is widely usable); (2) the heating rates of the fuselage, load factors and dynamic pressures are calculated along the flight path and are used for the assessment of the path; (3) the earth is assumed to be a sphere and the revolution is neglected (the angular velocity of the rotation is assumed to be constant); (4) a U.S. 62 standard atmosphere table is used; (5) it contains the models of the westerly wind, the steady wind in the low altitude, the gusts and the wind shears. The contents of the program and the construction of the mathematical model are described and the good results of the evaluation are presented in which the three degrees of freedom flight simulation program was tested using the data of the space shuttle of U.S.A. NASDA

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A91-10345#
THREE-DIMENSIONAL COMBUSTOR PERFORMANCE VALIDATION WITH HIGH-DENSITY FUELS
N. K. RIZK and H. C. MONGIA (General Motors Corp., Indianapolis, IN) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 660-667. Previously cited in issue 09, p. 1326, Accession no. A89-25193. refs
(Contract F33615-86-C-2604)
Copyright

A91-10966
HYDROGEN IN HIGH-SPEED AIR TRANSPORTATION
CARL-JOCHEN WINTER (DLR, Stuttgart, Federal Republic of Germany) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 172-180. refs
Copyright

This paper briefly reviews the history of hydrogen use in aviation and aerospace and goes on to discuss current international developments, which are centered around plans for supersonic/hypersonic aircraft using hydrogen as a fuel. The development work which must be accomplished before the first test flights can take place, possibly at the end of this century, includes rather straightforward technological challenges relating to components, systems and infrastructures and to safety and security considerations. A more complex challenge includes achieving environmental compatibility for this technology, which is well possible in the areas of producing and handling hydrogen fuel, but probably not in the area of end use, if the benefits of this fuel are to be fully exploited. Another formidable precondition is achieving an international political consensus that a transition from the established global hydrocarbon energy economy to a potential global hydrogen energy economy, in which aviation and aerospace could have a trailblazer function, is necessary, achievable, and urgent. Author

A91-11751
THERMAL BARRIER COATINGS - MICROSTRUCTURAL INVESTIGATION AFTER ANNEALING
L. LELAIT, S. ALPERINE, C. DIOT, and M. MEVREL (ONERA, Chatillon, France) (Materials Science and Engineering, Part A - Structural Materials: Properties, Microstructure and Processing, vol. A121, 1989, p. 475-482) ONERA, TP no. 1990-62, 1990, 9 p. refs
(ONERA, TP NO. 1990-62) Copyright

A study is conducted of the microstructures of plasma-sprayed (as-sprayed and annealed) yttria-partially stabilized zirconia thermal-barrier coatings representative of the state-of-the-art in thermal-barrier coatings for gas turbine hot-section components. The phase transformations observed upon annealing are typical of a slow return toward the phase-diagram equilibrium. TEM studies of perpendicularly observed thin foil specimens reveal fine microstructures which coarsen upon annealing; the character and morphology of these structures may be due to the precipitation of a high yttria-content t-double-prime phase which is due to strain-induced coarsening upon annealing. This phase may account for the great toughness of these ceramic coatings, in its function as a 'microcomposite'. O.C.

A91-11770#
RESEARCH AND DEVELOPMENT OF HIGH-PRESSURE-EXPONENT FUEL-RICH PROPELLANTS [*RECHERCHE ET DEVELOPPEMENT DE PROPERGOLS AEOBIES A FORT EXPOSANT DE PRESSION*]
BERTRAND FOUREST and CHRISTIAN MASSON (ONERA, Chatillon, France) (ICT, International Congress, 21st, Karlsruhe, Federal Republic of Germany, July 3-6, 1990) ONERA, TP no. 1990-91, 1990, 15 p. In French.
(ONERA, TP NO. 1990-91)

In order to adjust the fuel mass flow rate for the cruise conditions of rocket ramjets the pressure exponent of fuel-rich propellants must be high (or greater than 0.5). The burn-rate characteristics and the material component qualities required to maintain these high pressures are presented. Also, a study of ammonium perchlorate particle size is presented, and the effects of additives on the burn-rate are discussed. Numerical results of a burn-rate temperature sensitivity model and a steady-state combustion model are also presented. R.E.P.

A91-11776#
INFLUENCE OF CHROMIUM AND MOLYBDENUM ON THE STRUCTURAL STABILITY OF A HIGH STRENGTH DAMAGE TOLERANT P/M NICKEL BASED ALLOY FOR TURBINE DISKS
MICHEL MARTY, GILLES HUG, and ANDRE WALDER (ONERA, Direction des Materiaux, Chatillon, France) (Materials Research Society, Spring Meeting, San Francisco, CA, Apr. 16-20, 1990) ONERA, TP no. 1990-100, 1990, 7 p.
(ONERA, TP NO. 1990-100)

Six P/M Ni-based alloys applicable to turbine disk fabrication have been produced with Cr and Mo concentrations higher than those of the N18 alloy, for the sake of solid-solution strengthening, along lines recommended by the 'New-Phacomp' correlation method. In both N18's case and those of the modified alloys, the low volume fraction of phases rich in Cr, Mo, and Co which appear after long-term 700 C isothermal treatment is found not to induce brittleness. The creep rate is increased due to a decreasing volume fraction of the ultrafine gamma-prime, although the elongation-to-rupture remains unchanged. The effect of Cr is more important than that of Mo. O.C.

A91-11806
THE ROLE OF PRIMARY CARBIDES IN FATIGUE CRACK PROPAGATION IN AEROENGINE BEARING STEELS

A. IQBAL (University College, Muzaffarabad, Pakistan) and J. E. KING (Cambridge, University, England) International Journal of Fatigue (ISSN 0142-1123), vol. 12, July 1990, p. 234-244. Research supported by British Gas, PLC. refs
Copyright

Fatigue crack propagation, tensile and fracture toughness data for four aircraft engine bearing steels are reported. The steels involved are the through-hardened tool steels 18-4-1 (T1) and M50, and two similar carburized steels, RBD and Volvic. Crack growth data have been obtained at 20 C and 280 C to cover the range of oil temperatures experienced in aeroengine bearing operations. At 20 C, threshold Delta-K(th) values ranged between 3.5 and 4.5 MPa sq rt m with Paris exponents (m) of between 2.0 and 3.5. The lowest m-values were seen in the carburizing steels, which also exhibited lower Paris regime crack growth rates than M50 and 18-4-1. For all the steels, growth rates were higher at 280 C than 20 C, although there was a slight tendency for Delta-K(th) values to increase, probably associated with oxide-induced closure at 280 C. The effects of primary carbides, strength and toughness on fatigue crack growth behavior are discussed, in relation to the importance of static-mode cracking.
Author

A91-11883
A PROCESS MODEL FOR AGE HARDENING OF ALUMINIUM ALLOYS. I - THE MODEL
H. R. SHERCLIFF and M. F. ASHBY (Cambridge, University, England) *Acta Metallurgica et Materialia (ISSN 0956-7151)*, vol. 38, Oct. 1990, p. 1789-1812. Research supported by SERC. refs
Copyright

N91-10139# Rolls-Royce Ltd., Derby (England).
MULTI INDUSTRY APPLICATION OF ADVANCED MATERIALS
JOHN F. COPLIN 31 May 1989 20 p Presented in Japan, 31 May 1989
(PNR-90764; ETN-90-97963) Copyright Avail: NTIS HC/MF A03

Applications and market evolution of materials for aero engines are summarized. Early days market was provided by military engines. Civil airline market contributed to the market pull. Extra market pull can be provided by automotive industry. Technology developments, and production of high temperature/high resistance materials require new market pulls. At a time when military spending is going down in real money, and when a lower portion is going into aircraft and engines, it is found that lower cost machines made possible by ceramics and metal matrix developments can replace conventional concepts in the future. ESA

N91-10141 Illinois Univ., Chicago.
THE INSTABILITY OF COMBUSTION IN PROPULSION ENGINES Ph.D. Thesis
CHUN-PAO KUO 1989 219 p
Avail: Univ. Microfilms Order No. DA9015753

The proposed theory provides a theoretical prediction of the aerothermochemical sources of acoustic excitation, growth of instability, propagation, and resonant pressure oscillation as well as the transition instability model. The thesis presents the description of four major aerothermochemical sources: (1) monopole; (2) dipole; (3) quadrupole sources, which are respectively due to the non-steady propellant vaporization, combustion, aerodynamic drag and turbulence; and (4) the mechanical dilation caused by the time dependent convective motion of multi-phase flow. This is followed by the presentation of comprehensive analytical techniques to predict the strength of each aerothermochemical source by the theoretical procedure devised in non-steady spray group combustion and acoustic response of propellant injection/atomization, and properties of propellant. The numerical simulation of the detailed development of engine start-up instability is presented to demonstrate the dynamic growth of instability sources and the corresponding evolution of an acoustic instability during the start-up of a liquid-gas propulsion engine. Dissert. Abstr.

N91-10168# Rolls-Royce Ltd., Bristol (England).
CASTING ALLOYS FOR THE JET AGE
M. H. GRIFFITHS Derby, England 22 Jun. 1989 10 p Presented at POS Jnl (IBF) Meeting, Stratford-upon-Avon, England, 22 Jun. 1989
(PNR-90723; ETN-90-97948) Copyright Avail: NTIS HC/MF A02

The historical development of casting alloys applied to jet aero engines is summarized. Special attention is given to nickel based superalloys. Relevant developments are discussed highlighting important milestones achieved in terms of the effects of alloying elements and their constituent phases. The investment casting route is described. References to the various processing techniques now employed are made. These include directional solidification, single crystals, heat treatment and ceramic core technology. Current limitations and future developments designed to improve foundry practices are underlined. ESA

N91-10188# Pennsylvania State Univ., University Park.
THERMAL STABILITY OF JET FUEL Final Report, Sep. 1988 - Dec. 1989
SEMIH ESER, CHUNSHAN SONG, RONALD M. COPENHAVER, JANICE PERISON, and HAROLD H. SCHOBERT 1990 125 p
(Contract DE-AC22-88PC-88827)
(DE90-016801; DOE/PC-88827/T5) Avail: NTIS HC/MF A06

The principal objectives of this study were to investigate the thermal stability of a suite of alkylated phenols as typical trace contaminants in jet fuels and to determine the thermal stability of various fractions of a coal-derived and a petroleum-derived JP-8 jet fuel as well as the thermal stability of the unfractionated fuels. The thermal treatment experiments were carried out in nitrogen and air atmospheres (100 psig cold) using 15 ml microautoclave reactors. The reactors were heated in a fluidized sand bath at temperatures ranging from 150 C to 450 C. The samples of the coal-derived and petroleum-derived jet fuels were separated into five distillate fractions and these fractions were characterized by high-resolution gas chromatography-mass spectrometry (GC-MS). The thermal treatment products from the alkylated phenols were analyzed by 1-H and 13-C Nuclear Magnetic Resonance spectroscopy and gas chromatograhpy/mass spectroscopy.
DOE

N91-11107# Rolls-Royce Ltd., Derby (England).
INFLUENCE OF HEAT TREATMENT ON MICROSTRUCTURE AND PROPERTIES OF AN ADVANCED HIGH TEMPERATURE TITANIUM ALLOY
M. A. DAEUBLER (Motoren- und Turbinen-Union Muenchen G.m.b.H., Germany, F.R.), N. A. WALKER, and M. T. COPE 22 Nov. 1989 6 p Presented at EUROMAT 1989, European Conference on Advanced Materials and Processes, Aachen, Fed. Republic of Germany, 22-24 Nov. 1989
(PNR-90689; ETN-90-97932) Copyright Avail: NTIS HC/MF A02

The influence of the quench rate, aging treatment and re-solution heat treatment on the tensile behavior at 20, 600, and 600 C creep behavior of IMI 834 disc material is described. IMI 834 is a near alpha alloy with applications in aircraft engines as a compressor disc and blade material. IMI 834 offers considerable benefits over previous coarse grained beta processed alloys IMI 685 and IMI 829 in terms of strength, low cycle fatigue and creep resistance. The alloy is designed to be processed within the alpha plus beta phase field, for optimizing the balance of mechanical properties through microstructural modifications. ESA

N91-11128# Idaho National Engineering Lab., Idaho Falls.
THREE-DIMENSIONAL FLUID FLOW IN JFTOT (JET FUEL THERMAL OXIDATION TESTER)
C. H. OH, B. J. MERRILL, and R. P. WADKINS 1990 23 p Presented at the International Symposium on Gas-Liquid Two-Phase Flows in Conjunction with the Winter Annual Meeting of the ASME, Dallas, TX, 25-30 Nov. 1990
(Contract DE-AC07-76ID-01570)

(DE90-010929; EGG-M-90041; CONF-901109-3) Avail: NTIS HC/MF A03

This paper describes flow and temperature distributions in the Jet Fuel Thermal Oxidation Tester (JFTOT), a standard qualification apparatus for examining thermal stability of jet fuels. A three-dimensional numerical analysis is presented in this paper performed with the KIVA code. This work represents a preliminary attempt to calibrate a Computational Fluid Dynamics/Chemistry (CFDC) model using existing data from a modified JFTOT. Due to the limited amount of data, the deposition model used in this study is a global type Arrhenius relationship. Upon the findings of future JFTOT experiments, the relevant parameters to mass transfer, heat transfer, and fluid dynamics can be combined to define the thermal stability of jet fuel with a higher degree of accuracy. DOE

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A91-10336#
PYROMETRY FOR TURBINE BLADE DEVELOPMENT
E. SUAREZ and H. R. PRZIREMBEL (Pratt and Whitney Group, West Palm Beach, FL) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 584-589. Research supported by the Pratt and Whitney Group. Previously cited in issue 18, p. 3068, Accession no. A88-44736.
(Contract F33657-84-C-2137)
Copyright

A91-11027#
AN ACCURATE ACOUSTIC EMISSION LOCATION METHOD ADAPTED FOR COMPOSITE MATERIALS
A. BOUHERAOUA (AMDBA, S.A., Velizy-Villacoublay, France) IN: AECM-3: International Symposium on Acoustic Emission from Composite Materials, 3rd, Paris, France, July 17-21, 1989, Symposium Papers. Columbus, OH, American Society for Nondestructive Testing, Inc., 1989, p. 375-379.

A method which takes the anisotropy behavior of the material into consideration and which is based on calibrating the structure by exciting stimuli all over it is discussed. The stimulus is created by using an acoustic shock wave generated by an electric arc over the structure. The method includes an amplitude correction of each event by an attenuation grid. The accuracy is less than 1 cm, using a 2 cm step length and 1 s resolution, but can be increased by reducing the step length and changing the DT triggering mode. The method can be applied on complex structures like plane wings. B.P.

A91-11152
PRACTICAL DEVELOPMENTS IN HOLOGRAPHIC INTERFEROMETRY
R. J. PARKER (Rolls-Royce, PLC, Advanced Research Laboratory, Derby, England) (Meeting on Flow Visualisation Using Laser Techniques, University of Warwick, Coventry, England, May 10, 1989) Aeronautical Journal (ISSN 0001-9240), vol. 94, March 1990, p. 91-98. Research supported by the Ministry of Defence Procurement Executive. refs
Copyright

The use of holography for studying compressible flows is studied with attention given to applications to both two- and three-dimensional flow fields. A comparison is made between a holographic isodensity map and computer-generated density contours. It is concluded that holographic flow visualization is highly versatile and that it can be used in a variety of engineering applications. K.K.

A91-11199
LARGE-AMPLITUDE VIBRATIONS OF FREE-FREE TAPERED BEAMS
B. NAGESWARA RAO and G. VENKATESWARA RAO (ISRO, Vikram Sarabhai Space Centre, Trivandrum, India) Journal of Sound and Vibration (ISSN 0022-460X), vol. 141, Sept. 22, 1990, p. 511-515. refs
Copyright

The nonlinearity due to large deflections of beams of tapered configuration is examined by considering the exact moment-curvature relations. It is noted that this type of nonlinearity differs from that of Kuo-Kuang Hu and Kirmser (1971), where the moment is expressed as a cubic polynomial of linear curvature. The combined effects of the axial and transverse inertia terms in the equation of motion are also taken into account in the present formulation. The present nonlinear two-point boundary value problem is solved on the basis of a simple and reliable iterative numerical procedure. Natural frequency parameters for three types of tapered beams are also presented. It is determined that the effect of the geometric nonlinearity is of a softening type similar to that discussed by Kuo-Kuang Hu and Kirmser. L.K.S.

A91-11201
SYSTEMS RELIABILITY ASSESSMENT
A. G. COLOMBO, ED. (CEC, Joint Research Centre, Ispra, Italy) and A. SAIZ DE BUSTAMANTE, ED. (Madrid, Universidad Politecnica, Spain) Dordrecht, Netherlands, Kluwer Academic Publishers, 1990, 318 p. For individual items see A91-11202 to A91-11204.
Copyright

Theoretical and practical aspects of systems-reliability analysis are examined in reviews and reports. Topics addressed include stochastic processes, Markov chains, and systems availability; the Monte Carlo method, a practical approach to systems availability in the aircraft industry; reliability in nuclear-power-plant operations; fault-tree and event-tree analysis methods; systems modeling with Petri nets; and reliability modeling for failure-delay systems. Consideration is given to the Dylam approach to systems safety analysis, the analysis of protection-systems software, human reliability models, fixation errors, theories of mechanical reasoning under uncertainty, reliability parameter estimation by combination of data from various sources, and uncertainty modeling. T.K.

A91-11202
AVAILABILITY - A PRACTICAL APPROACH ON AEROSPACE INDUSTRY
S. SANZ FERNANDEZ DE CORDOBA (Construcciones Aeronauticas, S.A., Madrid, Spain) IN: Systems reliability assessment. Dordrecht, Netherlands, Kluwer Academic Publishers, 1990, p. 45-64. refs
Copyright

In the present paper, the concepts of reliability, maintainability and availability when used in connection to each other are reviewed. Mathematical models for availability of single and multiple systems are shown, and the dependence from reliability, maintainability and (for multisystems) the number of units involved is considered. Differences when dealing with plants or vehicles are reviewed. Author

A91-11219
COMPARISON OF MODAL PARAMETER ESTIMATION TECHNIQUES ON AIRCRAFT STRUCTURAL DATA
J. E. COOPER (Royal Aerospace Establishment, Farnborough, England) Mechanical Systems and Signal Processing (ISSN 0888-3270), vol. 4, March 1990, p. 157-172. refs
Copyright

Five global time domain parameter estimation methods, least squares, double least squares, total least squares, correlation fit and Smith least squares were compared using the same set of

impulse responses taken from the ground vibration test of an aircraft structure. The behavior of the modal parameter estimates was investigated for changes in the solution order and number of data points analyzed. The techniques produced comparable results for the dominant modes, although there were some differences in the estimates of the other modes. The correlation fit and Smith least squares approaches found equivalent estimates to the other methods while using much smaller computational model orders. Author

A91-11752#
CALCULATIONS OF THE SERVICE LIFE OF COMPONENTS UNDER SEVERE THERMOMECHANICAL LOADS [CALCULS DE DUREE DE VIE DES STRUCTURES SOUMISES A DES CHARGEMENTS THERMOMECANIQUES SEVERES]
J. L. CHABOCHE (Journees sur la Science et la Defense, Paris, France, May 15, 16, 1990) ONERA, TP no. 1990-63, 1990, 6 p. In French. refs
(ONERA, TP NO. 1990-63)

A study of proposed calculation methods for obtaining more reliable estimates of the service lives of aircraft or rocket engines subjected to high thermal stress is presented. Particular attention is given to a method employing inelastic analyses which is based on the definition of the cyclic stability of the material and on the existence of a pseudoperiodic response of the structure. Consideration is also given to simulation methods which take into account the true material response with either softening or hardening unstable cycling and coupling effects between deformation and damage. Detailed examples of the proposed methodology are presented, including the V-SEP joint of the Vulcain engine. R.E.P.

A91-11773#
L.D.V. APPLIED TO MEASUREMENTS BETWEEN TWO DISCS IN HIGH SPEED ROTATION
J. LABBE, P.-J. MICHARD, and M. IZARD (ONERA, Chatillon, France) (International Symposium on Applications of Laser Techniques to Fluid Mechanics, 5th, Lisbon, Portugal, July 9-12, 1990) ONERA, TP no. 1990-94, 1990, 5 p.
(ONERA, TP NO. 1990-94)

LDV is used on the 'CRETE' test rig in order to investigate the influence of the drag flow between two disks (about 600 mm diameter) in high rotation speed. Measurements are performed at room temperature in vertical planes parallel to axis of rotation. Results are compared to those obtained from a five holes pressure probe and a computation using 2D Navier Stokes code. Several configurations of injection flow are used and the rotation speed varied up to 12 000 rpm. Author

A91-11813 National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATIONAL TECHNOLOGY FOR FLIGHT VEHICLES; PROCEEDINGS OF THE SYMPOSIUM, WASHINGTON, DC, NOV. 5-7, 1990
AHMED K. NOOR, ED. (NASA, Langley Research Center, Hampton, Virginia, University, Charlottesville) and SAMUEL L. VENNERI, ED. (NASA, Materials and Structures Div., Washington, DC) Symposium sponsored by George Washington University, University of Virginia, and NASA. Computers and Structures (ISSN 0045-7949), vol. 37, no. 2, 1990, 130 p. For individual items see A91-11814 to A91-11824.
Copyright

Recent advances in computational fluid mechanics are discussed in reviews and reports. Sections are devoted to (1) the modeling of local phenomena and edge effects in solids, (2) stochastic modeling and simulation of fracture toughness, and (3) partioning strategy and new finite elements. Particular attention is given to global and local finite-element/spectral-boundary-element techniques for failure analysis, simulations of microfracture in metal-matrix composites, fatigue analysis of cracked anisotropic plates under stochastic loading, mathematical modeling for the analysis of nonlinear aircraft dynamics, physical and mathematical modeling of wave propagation in the Ariane 5 VEB structure, partitioning based on symmetry transformations, an FEM approach to adaptive reliability assurance, and time-domain FEMs for the large rotational dynamics of multibody systems. T.K.

A91-11974
DETECTION OF CONCEALED CORROSION DAMAGE IN AIRCRAFT STRUCTURES USING THE EDDY CURRENT METHOD [OBNARUZHENIE SKRYTYKH KORROZIONNYKH POVREZHDENII AVIATSIONNYKH KONSTRUKTSII VIKHRETOKOVYM METODOM]
V. N. UCHANIN and V. N. TSIRG (AN USSR, Fiziko-Mekhanicheskii Institut, Lvov, Ukrainian SSR) Fiziko-Khimicheskaia Mekhanika Materialov (ISSN 0430-6252), vol. 26, July-Aug. 1990, p. 103, 104. In Russian. refs
Copyright

The objective of the study was to investigate the possibility of using the eddy current method to detect the initial stage of pitting corrosion between stringers and skin panels without disassembling riveted joints or removing the paint. It is shown that eddy current fault detectors are capable of detecting corrosion pits deeper than 0.16 mm (about 5 percent of the thickness) without joint disassembly or paint removal. A procedure for the eddy current detection of local corrosion damage on the inaccessible surfaces of airframe structures has been developed. V.L.

A91-12036
RELIABILITY OF RESULTS OF THE CAPILLARY TESTING OF GAS TURBINE ENGINE COMPONENTS DURING REPAIRS [DOSTOVERNOST' REZUL'TATOV KAPILLIARNOGO KONTROLIA DETALEI GAZOTURBINNYKH DVIGATELEI PRI REMONTE]
IU. A. GLAZKOV Defektoskopiia (ISSN 0130-3082), no. 7, 1990, p. 62-70. In Russian. refs
Copyright

The problem of the reliability of capillary testing in gas turbine repair is examined with allowance for the particular technological route adopted during the repair. Examples of repair procedures that may affect the reliability of the results of capillary inspection are presented. These include chemical and mechanical stripping, grinding, polishing, heat treatment, deposition of chemical, diffusion, and other coatings, surface hardening treaments, and corrosion protection treatments. V.L.

A91-12421
A TECHNIQUE FOR MEASURING UNSTEADY AERODYNAMICS IN TURBOMACHINERY [DEVELOPPEMENT D'UNE TECHNIQUE DE MESURE INSTATIONNAIRE DANS LES TURBOMACHINES]
J. HUARD (ONERA, Chatillon, France) (DRET and Societe Francaise des Mecaniciens, Journees, Paris, France, Apr. 26, 27, 1990) Revue Francaise de Mecanique (ISSN 0373-6601), no. 3, 1990, p. 173-184. In French.
Copyright

A technique is presented that measures unsteady pressure downstream from the transonic rotor utilizing a total pressure probe with a high response pressure transducer. The development of new computation codes permits the unsteady characteristics of the flow to be obtained. Test results are described that show the unsteady measurements obtained downstream of a transonic rotor with inlet distortion. Algorithms used in the analyses are discussed in detail. It is also shown that static pressure can be determined with this system by taking into account the position angle of the transducer. It is concluded that the test analyses confirm the validity of this aerodynamic measuring technique. R.E.P.

A91-12688* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
VISCOUS DRAG REDUCTION IN BOUNDARY LAYERS
DENNIS M. BUSHNELL, ED. and JERRY N. HEFNER, ED. (NASA, Langley Research Center, Hampton, VA) Washington, DC, American Institute of Aeronautics and Astronautics, Inc. (Progress

in Astronautics and Aeronautics. Volume 123), 1990, 531 p. For individual items see A91-12689 to A91-12699.
Copyright

The present volume discusses the development status of stability theory for laminar flow control design, applied aspects of laminar-flow technology, transition delays using compliant walls, the application of CFD to skin friction drag-reduction, active-wave control of boundary-layer transitions, and such passive turbulent-drag reduction methods as outer-layer manipulators and complex-curvature concepts. Also treated are such active turbulent drag-reduction technique applications as those pertinent to MHD flow drag reduction, as well as drag reduction in liquid boundary layers by gas injection, drag reduction by means of polymers and surfactants, drag reduction by particle addition, viscous drag reduction via surface mass injection, and interactive wall-turbulence control. O.C.

A91-12694*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RIBLETS
MICHAEL J. WALSH (NASA, Langley Research Center, Hampton, VA) IN: Viscous drag reduction in boundary layers. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 203-261. refs
Copyright

In addition to characterizing the various concepts reported in the literature on longitudinally-ribbed surface for aerodynamic surface drag reduction, the present development status evaluation of this technology correlates all available experimental data. An analysis of these data is then conducted to ascertain the parameters most directly involved in drag reduction, and to evaluate the effects which have thus far been exerted on turbulent boundary layer structures. Such advanced riblet techniques as compound and three-dimensional riblets, riblets in combination with large-eddy breakup devices, and riblets with suction/blowing, are also discussed. O.C.

A91-12754#
FULL-POTENTIAL, EULER, AND NAVIER-STOKES SCHEMES
ANTONY JAMESON (Princeton University, NJ) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 39-88. refs
Copyright

The present development status evaluation of CFD schemes solving the full-potential, Euler, and Navier-Stokes equations for purposes of aerodynamic characteristics prediction gives attention to upwind differencing and convergence acceleration in algorithms for potential flow, the treatment of complex geometry, the time-dependent formulation and space discretization of the Euler equations, total variation diminishing and time-stepping schemes, and boundary layer corrections in viscous flow calculations. Solutions of the Reynolds-averaged Navier-Stokes equations are noted to be entirely feasible for both two- and three-dimensional flows; in addition, basic numerical algorithms for the treatment of viscous and compressible flows with shock waves are now available. O.C.

A91-12775#
FUTURE DIRECTIONS FOR APPLIED COMPUTATIONAL FLUID DYNAMICS
RICHARD G. BRADLEY (General Dynamics Corp., Fort Worth, TX) IN: Applied computational aerodynamics. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 889-901. Research supported by the General Dynamics Corp. refs
Copyright

In order for CFD to fulfill its emerging destiny as the supreme aerodynamic design method, attention must be given to several *major practical design-requirement considerations. It is noted* that the accuracy of a CFD solution is subject to limitation by (1) the appropriateness of its governing equations' representation of dominant flow features, (2) the numerical algorithm, which can be a source of numerical error in smoothing and convergence acceleration schemes, (3) grid resolution, which may not capture the scale of physical phenomena, and (4) physical models representing little-understood phenomena. The refinements *required in each such respect are discussed in conjunction with* anticipated computer software and hardware developments. O.C.

A91-12824
DETECTION OF AIRPLANES IN AERIAL IMAGERY
ROBERT H. MEYER and KEVIN K. TONG (Hughes Aircraft Co., Electro-Optical and Data Systems Group, El Segundo, CA) IN: Applications of digital image processing XII; Proceedings of the Meeting, San Diego, CA, Aug. 8-11, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 456-467. refs
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A proof-of-concept system for detecting aircraft in aerial imagery using their general shape is described. The method, which is based on a general two-dimensional object model suitable for aerial views, partly overcomes the problems of occlusion and poor object contrast. The method seems relatively insensitive to view angle and object orientation. C.D.

A91-12887#
SHOCK CAPTURING USING A PRESSURE-CORRECTION METHOD
JAMES J. MCGUIRK and GARY J. PAGE (Imperial College of Science, Technology, and Medicine, London, England) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1751-1757. Research supported by the Ministry of Defence Procurement Executive of England. Previously cited in issue 09, p. 1350, Accession no. A89-25450. refs
Copyright

A91-12888#
EXPERIMENTAL STUDY OF INSTABILITY MODES IN A THREE-DIMENSIONAL BOUNDARY LAYER
H. BIPPES and P. NITSCHKE-KOWSKY (DLR, Institut fuer Experimentelle Stroemungsmechanik, Goettingen, Federal Republic of Germany) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1758-1763. Previously cited in issue 18, p. 2854, Accession no. A87-42396. refs
Copyright

A91-12900#
VERTEX-BASED FINITE-VOLUME SOLUTION OF THE TWO-DIMENSIONAL NAVIER-STOKES EQUATIONS
SUNIL KUMAR CHAKRABARTTY (National Aeronautical Laboratory, Bangalore, India) AIAA Journal (ISSN 0001-1452), vol. 28, Oct. 1990, p. 1829-1831. refs
Copyright

A nodal point finite-volume space discretization scheme is presently used to solve the two-dimensional Reynolds-averaged Navier-Stokes equations with a thin-layer type of approximation and a simple two-layer algebraic eddy viscosity model. The highly efficient Runge-Kutta scheme is also used in conjunction with convergence-acceleration techniques. The results obtained for turbulent flow past a NACA 0012 airfoil are compared with available numerical and experimental results. O.C.

N91-10232# National Aeronautical Lab., Bangalore (India). Computational and Theoretical Fluid Dynamics Div.
WALL INTERFERENCE STUDIES Closing Report, Apr. 1983 - Jun. 1989
R. GOPINATH Jun. 1990 25 p
(PD-CF-9012) Avail: NTIS HC/MF A03

A closing report on the activity, Wall Interference Studies, is *presented. Codes were developed to assess wall interference* both for 2-D and 3-D cases, where the test section is ventilated, and validated. TSFOIL code was adapted for operation on the Univac computer. Instrumentation was developed for measuring the pressures on a control surface in the 1.2 m facility and once this

is installed in the above facility, correcting the data from it for wall interference effects should be a routine affair. Author

N91-10268*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A LASER-SHEET FLOW VISUALIZATION TECHNIQUE FOR THE LARGE WIND TUNNELS OF THE NATIONAL FULL-SCALE AERODYNAMICS COMPLEX
M. S. REINATH and J. C. ROSS Sep. 1990 15 p
(NASA-TM-102793; A-90082; NAS 1.15:102793) Avail: NTIS HC/MF A03 CSCL 14/2

A flow visualization technique for the large wind tunnels of the National Full Scale Aerodynamics Complex (NFAC) is described. The technique uses a laser sheet generated by the NFAC Long Range Laser Velocimeter (LRLV) to illuminate a smoke-like tracer in the flow. The LRLV optical system is modified slightly, and a scanned mirror is added to generate the sheet. These modifications are described, in addition to the results of an initial performance test conducted in the 80- by 120-Foot Wind Tunnel. During this test, flow visualization was performed in the wake region behind a truck as part of a vehicle drag reduction study. The problems encountered during the test are discussed, in addition to the recommended improvements needed to enhance the performance of the technique for future applications. Author

N91-10297# Rolls-Royce Ltd., Derby (England).
INTRODUCTION: NEEDS AND APPROACHES TO RELIABILITY AND QUALITY ASSURANCE IN DESIGN AND MANUFACTURE
A. C. PICKARD 6 Oct. 1989 8 p Presented at AGARD Damage Tolerance Concept Review Conference, Brussels, Belgium, 1-6 Oct. 1989
(PNR-90683; ETN-90-97930) Copyright Avail: NTIS HC/MF A02

In the damage tolerance approach, for improving the integrity of aero engines, reliability, and quality assurance issues are discussed. The implications of the following aspects on the damage tolerance concept are investigated: component material specifications and standards, controls on manufacturing processes, design systems and quality assurance. The subjects reviewed in the workshop on reliability and quality assurance are given. ESA

N91-10298# Rolls-Royce Ltd., Derby (England).
TOTAL QUALITY MANAGEMENT AT ROLLS-ROYCE PLC
R. H. WEDGE 15 Sep. 1990 10 p Submitted for publication
(PNR-90759; ETN-90-97961) Copyright Avail: NTIS HC/MF A02

The Rolls-Royce concept concerning quality and quality management is reviewed. The work is focused on the business associated with aircraft gas turbine manufacture. The reasons for the adoption of quality assurance methods and the company's targets are justified. The distribution of responsibilities and tasks in the quality assurance chain is explained. Resulting from the management plans, more effort is accorded to elimination and prevention, so that less time is spent on detection and correction. ESA

N91-10301*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH IN STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS, 1990
JEAN-FRANCOIS M. BARTHELEMY, comp. and AHMED K. NOOR, comp. (George Washington Univ., Hampton, VA.) Washington Mar. 1990 283 p The 31st conference was held in Long Beach, CA, 2-4 Apr. 1990; sponsored by AIAA, ASME, ASCE, AHS, and ASC
(NASA-CP-3064; L-16735; NAS 1.55:3064) Avail: NTIS HC/MF A13 CSCL 20/11

The Structural Dynamics and Materials (SDM) Conference was held on April 2 to 4, 1990 in Long Beach, California. This publication is a compilation of presentations of the work-in-progress sessions and does not contain papers from the regular sessions since those papers are published by AIAA in the conference proceedings.

N91-10303*# Technion - Israel Inst. of Tech., Haifa. Faculty of Aerospace Engineering.
REPEATED BUCKLING OF COMPOSITE SHEAR PANELS
JOSEF SINGER and TANCHUM WELLER *In* NASA, Langley Research Center, Research in Structures, Structural Dynamics and Materials, 1990 p 37-42 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20/11

Failures in service of aerospace structures and research at the Technion Aircraft Structures Laboratory have revealed that repeatedly buckled stiffened shear panels might be susceptible to premature fatigue failures. Extensive experimental and analytical studies have been performed at Technion on repeated buckling, far in excess of initial buckling, for both metal and composite shear panels with focus on the influence of the surrounding structure. The core of the experimental investigation consisted of repeated buckling and postbuckling tests on Wagner beams in a three-point loading system under realistic test conditions. The effects of varying sizes of stiffeners, of the magnitude of initial buckling loads, of the panel aspect ratio and of the cyclic shearing force, V sub cyc, were studied. The cyclic to critical shear buckling ratios, (V sub cyc/V sub cr) were on the high side, as needed for efficient panel design, yet all within possible flight envelopes. The experiments were supplemented by analytical and numerical analyses. For the metal shear panels the test and numerical results were synthesized into prediction formulas, which relate the life of the metal shear panels to two cyclic load parameters. The composite shear panels studied were hybrid beams with graphite/epoxy webs bonded to aluminum alloy frames. The test results demonstrated that composite panels were less fatigue sensitive than comparable metal ones, and that repeated buckling, even when causing extensive damage, did not reduce the residual strength by more than 20 percent. All the composite panels sustained the specified fatigue life of 250,000 cycles. The effect of local unstiffened holes on the durability of repeatedly buckled shear panels was studied for one series of the metal panels. Tests on 2024 T3 aluminum panels with relatively small unstiffened holes in the center of the panels demonstrated premature fatigue failure, compared to panels without holes. Preliminary tests on two graphite epoxy shear panels with small holes in the center showed no similar fatigue life degradation and no shift in failure mode. Further tests on the effect of holes are in progress. Author

N91-10316*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DIRECT USE OF LINEAR TIME-DOMAIN AERODYNAMICS IN AEROSERVOELASTIC ANALYSIS: AERODYNAMIC MODEL
J. A. WOODS and MICHAEL G. GILBERT *In its* Research in Structures, Structural Dynamics and Materials, 1990 p 207-220 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20/11

The work presented here is the first part of a continuing effort to expand existing capabilities in aeroelasticity by developing the methodology which is necessary to utilize unsteady time-domain aerodynamics directly in aeroservoelastic design and analysis. The ultimate objective is to define a fully integrated state-space model of an aeroelastic vehicle's aerodynamics, structure and controls which may be used to efficiently determine the vehicle's aeroservoelastic stability. Here, the current status of developing a state-space model for linear or near-linear time-domain indicial aerodynamic forces is presented. Author

N91-10317*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
COMPUTATION OF MAXIMUM GUST LOADS IN NONLINEAR AIRCRAFT USING A NEW METHOD BASED ON THE MATCHED FILTER APPROACH AND NUMERICAL OPTIMIZATION
ANTHONY S. POTOTZKY (Lockheed Engineering and Sciences Co., Hampton, VA.), JENNIFER HEEG, and BOYD PERRY, III *In its* Research in Structures, Structural Dynamics and Materials, 1990 p 221-229 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20/11

Time-correlated gust loads are time histories of two or more load quantities due to the same disturbance time history. Time correlation provides knowledge of the value (magnitude and sign) of one load when another is maximum. At least two analysis methods have been identified that are capable of computing maximized time-correlated gust loads for linear aircraft. Both methods solve for the unit-energy gust profile (gust velocity as a function of time) that produces the maximum load at a given location on a linear airplane. Time-correlated gust loads are obtained by re-applying this gust profile to the airplane and computing multiple simultaneous load responses. Such time histories are physically realizable and may be applied to aircraft structures. Within the past several years there has been much interest in obtaining a practical analysis method which is capable of solving the analogous problem for nonlinear aircraft. Such an analysis method has been the focus of an international committee of gust loads specialists formed by the U.S. Federal Aviation Administration and was the topic of a panel discussion at the Gust and Buffet Loads session at the 1989 SDM Conference in Mobile, Alabama. The kinds of nonlinearities common on modern transport aircraft are indicated. The Statical Discrete Gust method is capable of being, but so far has not been, applied to nonlinear aircraft. To make the method practical for nonlinear applications, a search procedure is essential. Another method is based on Matched Filter Theory and, in its current form, is applicable to linear systems only. The purpose here is to present the status of an attempt to extend the matched filter approach to nonlinear systems. The extension uses Matched Filter Theory as a starting point and then employs a constrained optimization algorithm to attack the nonlinear problem. Author

N91-10320*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATIC AND DYNAMIC AEROELASTIC CHARACTERIZATION OF AN AERODYNAMICALLY HEATED GENERIC HYPERSONIC AIRCRAFT CONFIGURATION
JENNIFER HEEG, MICHAEL G. GILBERT, and ANTHONY S. POTOTZKY *In its* Research in Structures, Structural Dynamics and Materials, 1990 p 249-261 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20/11

This work-in-progress presentation describes an ongoing research activity at the NASA Langley Research Center to develop analytical methods for the prediction of aerothermoelastic stability of hypersonic aircraft including active control systems. The objectives of this research include application of aerothermal loads to the structural finite element model, determination of the thermal effects on flutter, and assessment of active controls technology applied to overcome any potential adverse aeroelastic stability or response problems due to aerodynamic heating- namely flutter suppression and ride quality improvement. For this study, a generic hypersonic aircraft configuration was selected which incorporates wing flaps, ailerons and all-moveable fins to be used for active control purposes. The active control systems would use onboard sensors in a feedback loop through the aircraft flight control computers to move the surfaces for improved structural dynamic response as the aircraft encounters atmospheric turbulence. Author

N91-10321*# McDonnell Aircraft Co., Saint Louis, MO. Structural Research Div.
STRUCTURAL RISK ASSESSMENT AND AIRCRAFT FLEET MAINTENANCE
HERB SMITH, JR., C. R. SAFF, and TOM F. CHRISTIAN (Air Force Logistics Command, Robins AFB, GA.) *In* NASA, Langley Research Center, Research in Structures, Structural Dynamics and Materials, 1990 p 263-274 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20/11

In the present analysis, deterministic flaw growth analysis is used to project the failure distributions from inspection data. Inspection data is reported for each critical point in the aircraft. The data will indicate either a crack of a specific size or no crack. The crack length may be either less than, equal to, or greater than critical size for that location. Non-critical length cracks are projected to failure using the crack growth characteristics for that location to find the life when it will be at critical length. Greater-than-critical length cracks are projected back to determine the life at failure, that is, when it was at critical length. The same process is used as in the case of a non-critical crack except that the projection goes the other direction. These points, along with the critical length cracks are used to determine the failure distribution. To be able to use data from different aircraft to build a common failure distribution, a consistent life variable must be used. Aircraft life varies with the severity of the usage; therefore the number of flight hours for a particular aircraft must be modified by its usage factor to obtain a normalized life which can be compared with that from other aircraft. Author

N91-10333*# California Univ., San Diego, La Jolla. Dept. of Applied Mechanics and Engineering Sciences.
COMPARISON OF NASTRAN ANALYSIS WITH GROUND VIBRATION RESULTS OF UH-60A NASA/AEFA TEST CONFIGURATION Final Report
FLORENTINO IDOSOR and FRIEDER SEIBLE Sep. 1990 101 p Original contains color illustrations
(Contract NCC2-598)
(NASA-CR-184565; NAS 1.26:184565; SSRP-90/03) Avail: NTIS HC/MF A06; 4 functional color pages CSCL 20/11

Preceding program flight tests, a ground vibration test and modal test analysis of a UH-60A Black Hawk helicopter was conducted by Sikorsky Aircraft to complement the UH-60A test plan and NASA/ARMY Modern Technology Rotor Airloads Program. The 'NASA/AEFA' shake test configuration was tested for modal frequencies and shapes and compared with its NASTRAN finite element model counterpart to give correlative results. Based upon previous findings, significant differences in modal data existed and were attributed to assumptions regarding the influence of secondary structure contributions in the preliminary NASTRAN modeling. An analysis of an updated finite element model including several secondary structural additions has confirmed that the inclusion of specific secondary components produces a significant effect on modal frequency and free-response shapes and improves correlations at lower frequencies with shake test data. Author

N91-10335*# Florida Atlantic Univ., Boca Raton. Dept. of Ocean Engineering.
EXPERIMENTAL MEASUREMENT OF STRUCTURAL POWER FLOW ON AN AIRCRAFT FUSELAGE Progress Report
J. M. CUSCHIERI Jun. 1989 29 p
(Contract NAG1-685)
(NASA-CR-187352; NAS 1.26:187352) Avail: NTIS HC/MF A03 CSCL 20/11

An experimental technique is used to measure the structural power flow through an aircraft fuselage with the excitation near the wing attachment location. Because of the large number of measurements required to analyze the whole of an aircraft fuselage, it is necessary that a balance be achieved between the number of measurement transducers, the mounting of these transducers, and the accuracy of the measurements. Using four transducers mounted on a bakelite platform, the structural intensity vectors at locations distributed throughout the fuselage are measured. To minimize the errors associated with using a four transducers technique the measurement positions are selected away from bulkheads and stiffeners. Because four separate transducers are used, with each transducer having its own drive and conditioning amplifiers, phase errors are introduced in the measurements that can be much greater than the phase differences associated with the measurements. To minimize these phase errors two sets of measurements are taken for each position with the orientation of the transducers rotated by 180 deg and an average taken between the two sets of measurements. Results are presented and discussed. Author

N91-11140 Southampton Univ. (England).
VOICE COMMUNICATIONS IN THE COCKPIT NOISE ENVIRONMENT: THE ROLE OF ACTIVE NOISE REDUCTION

Ph.D. Thesis
PETER DAVID WHEELER 1986 259 p
Avail: Univ. Microfilms Order No. BRDX88858

The topic of voice communications in the cockpit noise environment of modern fast-jet aircraft and helicopters is addressed, and in particular, research undertaken in support of the development of a system for reducing the noise level at the operators' ear is described by acoustic cancellation within the ear defender, known as active noise reduction (ANR). The internal noise spectra of today's high performance fast-jet aircraft and military helicopters is described, and the complex interaction of acoustic noise transmission, speech, and microphone noise pick-up, which produces the total acoustic environment at the aircrews' ears, is discussed. Means of mathematically modelling the audio channel, quantifying the components identified above, and identifying areas of shortfall in performance are derived, leading to a procedure for the development of attenuation requirements, described as the communications audit. A model of the electroacoustic characteristics of the ANR ear defender assembly is presented and the sound field distribution within the ear defender/ear cavity, and its effect upon cancellation performance, is discussed. The extensive laboratory and flight testing of the ANR system that was undertaken is reviewed, paying particular attention to the measurement and analysis techniques employed in such testing. Finally, the performance characteristics of ANR are discussed and compared with the requirements previously established. Design limitations placed upon the system by the constraints of its area of application are described, and the scope for future improvements is considered. Dissert. Abstr.

N91-11174 Colorado Univ., Boulder.
APPLICATION OF COMPUTATIONAL FLUID DYNAMICS TO THREE-DIMENSIONAL BODIES IN HYPERSONIC FLOW Ph.D. Thesis
JAMES STEVENSON RYAN 1989 85 p
Avail: Univ. Microfilms Order No. DA9024865

Hypersonic aircraft are now being designed. For that work to be completed, improved computational tools are required. The flow simulation capabilities which are needed are being sought. In order to accomplish this, features of several existing codes were combined and enhanced. The Compressible Navier-Stokes (CNS) computer code solves the thin-layer Navier-Stokes equations in three dimensions for arbitrary vehicle shapes. The solver can capture strong or weak shocks, and can model separated flow. Boundary-layer turbulence is accounted for empirically by use of the Baldwin-Lomax turbulence model. The code uses ideal gas assumptions or an equilibrium real gas model. Geometries are gridded in a zonal fashion, allowing for flexible convergence strategies and use of the best available equation set for each zone. The grid on which the computations are performed is critical to the efficient generation of accurate solutions. Some of the criteria for grid quality are discussed, and a simple method of adapting grids to supersonic flow fields is presented. The code was tested against analytical, experimental, and numerical results, and shows excellent agreement for critical quantities such as heat transfer and skin friction. The zonal approach of the code and its modular structure allow for future inclusion of internal flow options, more complex geometrical models, nonequilibrium air chemistry, combustion chemistry, and other improvements. Dissert. Abstr.

N91-11197# European Space Agency, Paris (France).
PARALLELIZATION ON A MULTI-PROCESSOR SYSTEM OF A SOLVING METHOD FOR THE UNSTEADY NAVIER-STOKES EQUATIONS AT HIGH REYNOLDS NUMBERS
LAURE MANE Aug. 1990 144 p Transl. into ENGLISH of Parallelisation sur un Systeme Multiprocesseur d'une Methode de Resolution des Equations de Navier-Stokes Instationnaires a Grands Nombres de Reynolds (Paris, France, ONERA), 1987 111 p Original language document was announced as N88-26632 (ESA-TT-1116; ONERA-NT-1987-8; ETN-90-97999) Avail: NTIS HC/MF A07

A method for the simulation of viscous incompressible flows around an airfoil is presented which provides resolution of the two dimensional Navier-Stokes equations in stream function and vorticity function formulation. High precision finite difference schemes and Alternating Directions Implicit (ADI) techniques are combined. The algorithm was implemented on a multiprocessor to cope with the parallelism required by ADI methods. The parallelization of the algorithm and performance levels of the parallel code are set out. Pulsed-start numerical simulations on a NACA 0012 airfoil were performed for various airfoil incidence angles and for Reynolds number up to 10 to the 5th power. The phenomena obtained, the influence of the calculation parameters are discussed and comparison between numerical and experimentally visualized results validates the method. ESA

N91-11243# Laboratorio Nacional de Engenharia e Tecnologia Industrial, Lisbon (Portugal).
SHORT CRACK BEHAVIOUR IN AL-LI ALLOY 2090
M. HELENA CARVALHO and M. DEFREITAS (Lisbon Univ., Portugal) *In* AGARD, Short-Crack Growth Behaviour in Various Aircraft Materials 17 p Aug. 1990
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Within the AGARD Cooperative Test Program on the behavior of short cracks, a common airframe aluminium alloy (2024-T3) was investigated and the significance of the short crack effect analyzed from tests conducted on a single edge notched fatigue specimens of sheet material. The follow up Supplemental Test Program dealt with other alloys such a Ti6Al4V, steel 4340, Al 7075 and Al-Li 2090, all of them of interest Al-Li alloy at LNETI/CEMUL are described. Author

N91-11246# Aeronautical Research Inst. of Sweden, Bromma. Dept. of Structures.
SHORT CRACK GROWTH UNDER REALISTIC FLIGHT LOADING: MODEL PREDICTIONS AND EXPERIMENTAL RESULTS FOR AL 2024 AND AL-LI 2090
A. F. BLOM *In* AGARD, Short-Crack Growth Behaviour in Various Aircraft Materials 15 p Aug. 1990 Sponsored by Defense Materials Administration
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The swedish contribution to the AGARD effort on short fatigue crack growth includes various experimental investigations on the aluminum alloys Al 2024-T3 and Al-Li 2090-T8E41. These two materials were subjected both to constant amplitude loading, at stress ratios R = -2, -1, 0, and 0.5 and also to spectrum loading with the standardized load sequences FALSTAFF and TWIST, representative for the lower wing surface of fighter and civil aircraft, respectively. The TWIST sequence was also used to generate long crack growth data for the two alloys. The experimental results are summarized and numerical predictions by means of a modified Dugdale-Barenblatt model originally proposed by Newman are also included. Numerical results correspond well to the observed experimental behavior for most of the performed tests. Author

N91-11247*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE GROWTH OF SHORT CRACKS IN 4340 STEEL AND ALUMINUM-LITHIUM 2090
M. H. SWAIN, R. A. EVERETT (Army Aviation Systems Command, Hampton, VA.), JAMES C. NEWMAN, JR., and E. P. PHILLIPS *In* AGARD, Short-Crack Growth Behaviour in Various Aircraft Materials 30 p Aug. 1990 Sponsored by NASA
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 20/11

The objectives were to investigate crack initiation characteristics and short crack growth behavior for Al-Li 2090 and for 4340 steel and to evaluate the ability of a closure-based crack-growth model to predict fatigue crack growth rates and total fatigue lives for the steel. Single-edge-notched tension specimens of each alloy were used to obtain the short crack growth rate information via an acetate replica technique. In addition to constant amplitude loading, tests on the steel were conducted using the

Felix/28 variable amplitude spectrum (a shortened form of a standard loading sequence for fixed or semi-rigid helicopter rotors). The short crack growth rates were compared to those for long cracks grown under similar loading conditions. Metallurgical features associated with crack initiation are discussed. For Al-Li 2090 under R = -1 loading, the short cracks grew well below the long crack threshold and grew at acute angles to the loading axis. For 4340 steel under constant amplitude loading at R = 0.5 and 0 and for the Felix/28 spectrum loading, short-crack growth rates agreed well with long-crack growth rates, even near the long-crack threshold. A slight short-crack effect, growth below the long-crack threshold, was observed at R = -1. Fatigue lives were found to depend on the size and type of initiation site, especially for the Felix/28 loading sequence. A semi-empirical crack-growth model incorporating crack-closure effects was used to predict crack growth rates and total fatigue lives of notched 4340 steel specimens. An initial defect size and shape typical of those identified in this steel was assumed for the life predictions. For all loading conditions, reasonable agreement was found between measured and predicted values for both crack growth rates and fatigue lives. Author

N91-11248# National Aerospace Lab., Amsterdam (Netherlands).
SHORT AND LONG FATIGUE CRACK GROWTH IN 2024-T3 UNDER FOKKER 100 SPECTRUM LOADING
R. J. H. WANHILL and L. SCHRA *In* AGARD, Short-Crack Growth Behaviour in Various Aircraft Materials 26 p Aug. 1990 Sponsored by Netherlands Agency for Aerospace Programs
Copyright Avail: NTIS HC/MF A09; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

The behavior of short and long fatigue cracks in the widely used damage tolerant aluminum alloy 2024-T3 was compared using flight simulation loading representatives for the Fokker 100 wing/fuselage structure. The results showed that the apparently anomalous behavior of short cracks is not significant for durability analysis of the current wing/fuselage structure. Also the data provide a reference for evaluating new, candidate materials for durable wing/fuselage structures in transport aircraft. Author

N91-11266# Rolls-Royce Ltd., Bristol (England).
EXPERIENCES IN THE USE OF ABAQUS FOR CREEP ANALYSIS
E. O. A. PREMPEH Derby, England 7 Sep. 1989 12 p Presented at ABAQUS Users Meeting, Harwell, England, 7 Sep. 1989
(PNR-90705; ETN-90-97937) Copyright Avail: NTIS HC/MF A03

Some of the experiences gained in the use of ABAQUS program for creep analysis are reported. The ABAQUS program was used to determine the creep behavior of aircraft engine components subject to elevated temperatures and stress. Considerable difficulty was experienced in obtaining any creep solution in the initial stages. Once the causes of the difficulties were identified and resolved, the creep law subroutine became properly synchronized with the ABAQUS program. Comparisons of the results with solutions of creep analyses using other programs were found to be satisfactory. A suggestion for improving the ABAQUS user manual is presented. ESA

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A91-11072#
TIME SERIES AND CORRELATION OF PULSATIONS OBSERVED SIMULTANEOUSLY BY TWO AIRCRAFT
ANDREW R. OCHADLICK, JR. (U.S. Navy, Naval Air Development Center, Warminster, PA) Geophysical Research Letters (ISSN 0094-8276), vol. 17, Oct. 1990, p. 1889-1892. refs

Two aircraft were used as mobile geomagnetic observatories to study the similarity of 2-25-s pulsations as a function of aircraft separation (1.6-4600 km). An analysis of the results obtained indicates that the strong similarity of pulsations weakens quickly at a distance of about 150 km, which is close to the ionospheric height and thus suggestive of a strong ionospheric control of the spatial coherence of pulsations. V.L.

A91-12537*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AIRCRAFT EN ROUTE NOISE ANNOYANCE
DAVID A. MCCURDY (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-4028) Copyright

Results are reported from a laboratory experiment conducted in order to quantify the annoyance experienced by people on the ground in response to en route noise (ERN) generated by aircraft at cruise conditions. Objectives included the comparison of annoyance responses to ERN with the annoyance responses to takeoff and landing noise; the comparison of the annoyance responses to advanced turboprop aircraft ERN with those of the turbofan ERN; and also the ability of aircraft noise measurement procedures and corrections to predict annoyance to ERN. Tests were conducted at the Langley Acoustics Research Laboratory on 32 human subjects selected at random. Subjects judged the annoyance level of 24 Propfan Test Assessment advanced turboprop ERN stimuli, 18 conventional turbofan ERN stimuli, and 60 conventional turboprop and turbofan takeoff and landing noise stimuli. Analysis of resulting data compared annoyance responses to different aircraft types and operations, examined the ability of current noise measurement and correction procedures to predict annoyance ERN, and calculated optimum duration correction magnitudes for ERN. L.K.S.

A91-12538#
SOUND INSULATION OF DWELLINGS AROUND AIRPORTS - OBJECTIVE AND SUBJECTIVE MEASURES AND FINDINGS
DAVID BROWN (Wyle Laboratories, El Segundo, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 7 p. refs
(AIAA PAPER 90-4029) Copyright

Aircraft noise is a major problem to many residents living near airports. This problem includes disruption of many activities such as reading, conversation, listening to TV or radio, and sleep. The retrofit application of sound insulation to dwellings near various airports in the U.S. has recently become one of the more viable and rewarding means of noise mitigation, mainly due to its demonstrated effectiveness and the availability of funding mechanisms. This paper presents results from a number of projects in terms of objective (noise metric) evaluations and subjective (opinion survey) attitudes which illustrate the primary benefits to affected residents. Author

A91-12541#
SONIC BOOM ENVIRONMENT UNDER A SUPERSONIC MILITARY OPERATING AREA
KENNETH J. PLOTKIN, VIJAY R. DESAI, MICHAEL J. LUCAS,

CAREY L. MOULTON (Wyle Laboratories, Arlington, VA), and RUBEN G. GARZA AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 9 p. Research sponsored by USAF. refs
(AIAA PAPER 90-4032) Copyright

The paper examines results of a six-month sonic boom measurement program conducted in the Lava/Mesa airspace at the White Sands Missile Range, New Mexico which is used for supersonic air combat maneuver (ACM) training, primarily by F-15s from Holloman AFB. All flight activity data for the airspace were reviewed and correlated with measured booms, and a sample of ACMI tracking data was obtained for detailed analysis of particular events and to develop an understanding of how and when supersonic events occur. The measurement program is described in detail, and statistical analysis of sonic booms identified with ACM activity is performed. Analyses include development of models for the long-term C-weighted day-night level and frequency of occurrence of booms at various locations in the airspace, and the probability distribution of boom amplitudes at a given location. The nature of sonic booms occurring in the airspace was also examined in order to resolve the differences between measurements and earlier predictions. L.K.S.

N91-10548*# Electro Magnetic Applications, Inc., Denver, CO.
DEVELOPMENT AND APPLICATION OF LINEAR AND NONLINEAR METHODS FOR INTERPRETATION OF LIGHTNING STRIKES TO IN-FLIGHT AIRCRAFT Final Report
TERENCE RUDOLPH, RODNEY A. PERALA, CALVIN C. EASTERBROOK, and STEVEN L. PARKER Sep. 1986 441 p
(Contract NAS1-17748)
(NASA-CR-3974; NAS 1.26:3974; EMA-85-R-37) Avail: NTIS HC/MF A19 CSCL 04/2

Since 1980, NASA has been collecting direct strike lightning data by flying an instrumented F-106B aircraft into thunderstorms. The continuing effort to interpret the measured data is reported here. Both linear and nonlinear finite difference modeling techniques are applied to the problem of lightning triggered by an aircraft in a thunderstorm. Five different aircraft are analyzed to determine the effect of aircraft size and shape on lightning triggering. The effect of lightning channel impedance on aircraft response is investigated. The particle environment in thunderstorms and electric field enhancements by typical ice particles is also investigated. Author

N91-10960*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TERMINAL WEATHER INFORMATION MANAGEMENT Abstract Only
ALFRED T. LEE *In* NASA, Langley Research Center, Aviation Safety/Automation Program Conference p 271-274 Oct. 1990
Avail: NTIS HC/MF A12 CSCL 04/2

Since the mid-1960's, microburst/windshear events have caused at least 30 aircraft accidents and incidents and have killed more than 600 people in the United States alone. This study evaluated alternative means of alerting an airline crew to the presence of microburst/windshear events in the terminal area. Of particular interest was the relative effectiveness of conventional and data link ground-to-air transmissions of ground-based radar and low-level windshear sensing information on microburst/windshear avoidance. The Advanced Concepts Flight Simulator located at Ames Research Center was employed in a line oriented simulation of a scheduled round-trip airline flight from Salt Lake City to Denver Stapleton Airport. Actual weather en route and in the terminal area was simulated using recorded data. The microburst/windshear incident of July 11, 1988 was re-created for the Denver area operations. Six experienced airline crews currently flying scheduled routes were employed as test subjects for each of three groups: (1) A baseline group which received alerts via conventional air traffic control (ATC) tower transmissions; (2) An experimental group which received alerts/events displayed visually and aurally in the cockpit six miles (approx. 2 min.) from the microburst event; and (3) An additional experimental group received displayed alerts/events 23 linear miles (approx. 7 min.) from the microburst event. Analyses of crew communications and decision times showed a marked improvement in both situation awareness and decision-making with visually displayed ground-based radar information. Substantial reductions in the variability of decision times among crews in the visual display groups were also found. These findings suggest that crew performance will be enhanced and individual differences among crews due to differences in training and prior experience are significantly reduced by providing real-time, graphic display of terminal weather hazards. Author

N91-11006# European Organization for the Safety of Air Navigation, Brussells (Belgium). Engineering Directorate.
DEVELOPMENTS TO ENHANCE METEOROLOGICAL FORECASTING FOR AIR TRAFFIC SERVICES
M. E. COX and D. A. FORRESTER (Meteorological Office, Bracknell, England) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 12 p May 1990
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In the future, the quality of the meteorological data available for use both in ground-based systems and on aircraft will become even more important as ATC strives to handle increasing volumes of traffic in the most efficient manner. An indication of the effect of errors in meteorological data on the precision of predictions of aircraft trajectories is discussed and the variability of wind and temperature is examined, showing the influence of location, altitude and season, in the European area. An outline of present-day forecasting methods follows (the data used and accuracies achieved are included). Potential sources of improvements are then discussed with the emphasis being placed on the use of aircraft-derived data (details are given of the accuracy of such data, possible methods of recovery, and their application within the Meteorological Services). The impact is described of turbulence on both the safety of air traffic and the accuracy of flight profile predictions (possible methods of providing aircraft with the means for the automatic reporting of turbulence are included). Some experimental work either performed or being planned in the European area is also described, aimed at improving the quality of the meteorological data made available for ATS purposes as a result of using data recovered from aircraft through both satellite and ground-based (Mode S SSR) systems. Author

N91-11307# Rolls-Royce Ltd., Derby (England).
COMMERCIAL AIRCRAFT AND THE ENVIRONMENT
ANTHONY B. WASSEL 15 Mar. 1990 15 p Presented at Aeropropulsion 1990, Paris, France, Mar. 1990
(PNR-90687; ETN-90-97931) Copyright Avail: NTIS HC/MF A03

The impact of both noise and emission control on engine design is considered. New technology developed to meet the regulatory objectives are underlined. The reduction of noise in turbofan engines is discussed. Conflicting requirements and considerations of safety are stressed. Subsonic and supersonic noise generation and regulations proposed are reviewed. The reduction in CO2 and other emissions from aircraft propulsion systems are investigated. ESA

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A91-11154
MIXED STRUCTURED-UNSTRUCTURED MESHES FOR AERODYNAMIC FLOW SIMULATION
N. P. WEATHERILL (Swansea, University College, Wales) Aeronautical Journal (ISSN 0001-9240), vol. 94, April 1990, p. 111-123. Research supported by the Aircraft Research Association and Royal Aerospace Establishment. refs
Copyright

A composite approach in computational aerodynamics, which uses both structured and unstructured mesh generation for aerodynamic flow simulation, and the possible benefits of this approach, are discussed. An algorithm which can solve Euler equations for inviscid flow on such meshes is suggested. Three applications of the approach are described, which include: (1) use of regions of assembled triangles to improve a structured mesh of poor quality, (2) use of local regions of unstructured mesh, within a globally structured mesh, to obtain discrete regions in geometrically complicated aerodynamic configurations, and (3) use of mesh/flow adaptivity within a structured mesh. B.P.

A91-11353
A SELF-ORGANIZING STOCHASTIC CONTROL SYSTEM ADAPTABLE TO CHANGING PERTURBATION CHARACTERISTICS [SAMOORGANIZUIUSHCHAIASIA STOKHASTICHESKAIA SISTEMA UPRAVLENIIA, PRISPOSABLIVAIUSHCHAIASIA K IZMENIAIUSHCHIMSIA KHARAKTERISTIKAM VOZMUSHCHENII]
A. I. PETROV and G. O. STETSKO (Moskovskii Aviatsionnyi Institut, Moscow, USSR) Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 312, no. 2, 1990, p. 284-288. In Russian. refs
Copyright

The problem of the synthesis of adaptive control laws for systems with a stochastic structure functioning under conditions of uncontrolled non-Gaussian perturbations with randomly varying characteristics is examined with particular reference to the development of high-precision control systems for flight vehicles. An optimal solution to the problem is obtained in a class of self-organizing systems. Studies of synthesized self-organizing control systems indicate that the algorithms proposed here ensure adaptability to the effect of perturbations and to changes in their characteristics, making it possible to improve the precision of flight vehicle control. V.L.

N91-10986# National Aerospace Lab., Amsterdam (Netherlands).
THE APPLICATION OF TRAJECTORY PREDICTION ALGORITHMS FOR PLANNING PURPOSES IN THE NETHERLANDS ATC-SYSTEM
J. N. P. BEERS, T. B. DALM, J. M. TENHAVE, and H. VISSCHER (Department of Civil Aviation, An Hoofddorp, Netherlands) *In* AGARD, Aircraft Trajectories: Computation, Prediction, Control, Volume 2: Air Traffic Handling and Ground-Based Guidance of Aircraft. Part 4: Air Traffic Handling. Part 5: Guidance of Aircraft in a Time-Based Constrained Environment. Surveillance. Part 7: Meteorological Forecasts. Part 8: Aircraft Operation in Air Traffic Handling Simulation 11 p May 1990 Previously announced as N89-20115
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The Netherlands ATC-environment, the basic set-up of the trajectory prediction module, improvements realized, and the performance figures are presented. Applications of the trajectory prediction results in the system are listed, including data distribution rules, presentation of estimated times of arrival, boundary estimates, and, in particular, long term detection of conflicts for overflying aircraft, planning of inbound traffic for Schiphol airport, and planning of departure times for an efficient engine start-up procedure. Author

N91-11416# Rolls-Royce Ltd., Derby (England).
THE ROLE OF PROCESS MODELLING IN MANUFACTURE AND DESIGN
G. J. S. HIGGINBOTHAM 9 Sep. 1989 20 p Presented at the 9th ISABE Symposium, Athens, Greece, 4-9 Sep. 1989
(PNR-90702; ETN-90-97936) Copyright Avail: NTIS HC/MF A03

The relationship between the design and manufacturing functions in the development of aircraft engine components is examined. The design manufacturing interface is addressed from a total engineering process point of view. It identifies how the introduction of computer modeling of manufacturing processes can lead to reduced lead times and speedier introduction of new components, processes or alloys into applications for aircraft engine power plants, and compares this approach with the traditional iterative development process. The target for computer modeling are to simultaneously achieve a right first time design while establishing clear process manufacturing rules. It is shown that in this way, both risk and cost can be reduced. ESA

N91-11424# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Hubschrauber und Flugzeuge.
USE OF THE VP-200 COMPUTER FOR AEROTHERMODYNAMIC PROBLEMS
LUCIANO FORNASIER 8 Dec. 1989 11 p Presented at International Workshop on Supercomputing Tools for Science and Engineering, Pisa, Italy, 4-7 Dec. 1989
(MBB/FE122/S/PUB/388; ETN-90-97848) Copyright Avail: NTIS HC/MF A03

The implementation and application of four aerodynamic flow solvers on the Siemens VP-200 vector processor is presented. The experience from all cases demonstrates the benefits of vector processing for aerodynamic codes characterized by very large computational effort. The high autovectorization level obtainable by the VP-200 allows optimal performance to be achieved with speedup factors between 20 to 30 while requiring very marginal code modifications. ESA

N91-11430*# Institute for Computer Applications in Science and Engineering, Hampton, VA.
PARALLELIZED RELIABILITY ESTIMATION OF RECONFIGURABLE COMPUTER NETWORKS Final Report
DAVID M. NICOL, SUBHENDU DAS (College of William and Mary, Williamsburg, VA.), and DAN PALUMBO Sep. 1990 25 p Submitted for publication
(Contract NAS1-18605; NAG1-787; NAG1-1132; NSF ASC-88-19373)
(NASA-CR-182101; ICASE-90-60; NAS 1.26:182101) Avail: NTIS HC/MF A03 CSCL 09/2

A parallelized system, ASSURE, for computing the reliability of embedded avionics flight control systems which are able to reconfigure themselves in the event of failure is described. ASSURE accepts a grammar that describes a reliability semi-Markov state-space. From this it creates a parallel program that simultaneously generates and analyzes the state-space, placing upper and lower bounds on the probability of system failure. ASSURE is implemented on a 32-node Intel iPSC/860, and has achieved high processor efficiencies on real problems. Through a combination of improved algorithms, exploitation of parallelism, and use of an advanced microprocessor architecture, ASSURE has reduced the execution time on substantial problems by a factor of one thousand over previous workstation implementations. Furthermore, ASSURE's parallel execution rate on the iPSC/860 is an order of magnitude faster than its serial execution rate on a Cray-2 supercomputer. While dynamic load balancing is necessary

for ASSURE's good performance, it is needed only infrequently; the particular method of load balancing used does not substantially affect performance. Author

N91-11433 California Univ., Los Angeles.
CONSTRAINED OPTIMIZATION APPROACH TO FEEDBACK CONTROL OF STATE-AUGMENTED SYSTEMS Ph.D. Thesis
WON-ZON CHEN 1990 124 p
Avail: Univ. Microfilms Order No. DA9022003

The Linear/Quadratic (LQ) optimal control theory, introduced by Kalman, has attracted much attention due to the guaranteed control optimality with respect to a quadratic performance measure, and its inherent capability to handle Multiple-Input-Multiple Output (MIMO) systems. The LQ design process can be automated through an array of analytical procedures, greatly easing the design efforts. However, unsatisfactory performance and lack of robustness were experienced with the LQ design method. Numerous methods have been proposed in the past attempting to solve either the performance and/or the robustness problems of LQ optimal control theory. A method that combines the merits of time-domain and frequency-domain techniques for designing feedback control systems is studied. The approach involves the use of state augmentation to introduce dynamic compensators for performance enhancement first and, then, optimize a quadratic cost functional with the constraint of minimum multivariable stability margins. This *robustness constrained optimization of quadratic performance* measure approach is direct and matches well with the formulation and design objectives of real-life design problems. Multivariable examples of designing aircraft flight control laws with state feedback and output feedback are included to illustrate and demonstrate the effectiveness of the approach. The subject of how to augment the state of a dynamic system for performance enhancement is also examined from the standpoint of controllability, feedback equivalence, and minimum order. Dissert. Abstr.

N91-11473# European Space Agency, Paris (France).
SOLUTION OF THE TWO-DIMENSIONAL EULER EQUATIONS BY A FINITE VOLUME DISCRETIZATION ON UNSTRUCTURED TRIANGULAR MESHES
ARNO RONZHEIMER Aug. 1990 97 p Transl. into ENGLISH of Loesung der Zweidimensionalen Euler-Gleichungen Durch Eine Finite-Volumen-Diskretisierung auf Unstrukturierten Netzen (Brunswick, Fed. Republic of Germany, DFVLR), Jul. 1988 82 p Original language document was announced as N89-15672
(ESA-TT-1135; DFVLR-FB-88-34; ETN-90-98001) Avail: NTIS HC/MF A05; original German version available from DFVLR, Wissenschaftliches Berichtwesen, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, 28 Deutsches marks

The main reason for using unstructured grids is the possibility of simulating flows around complicated geometries, for which the generation of structured grids fitted to the body is substantially more expensive. The starting point of the study is a solution method based on a two dimensional cell corner scheme for structured grids. The various components of the solution procedure were adapted to the special requirements of unstructured triangular grids. The solution method described is checked by calculating subsonic and transonic flows around aerofoils. The effects of artificial dissipation are investigated and the influence of several acceleration techniques is discussed. ESA

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A91-11786#
EXPERIMENTAL STUDY OF HIGH-SPEED IMPULSIVE ROTOR NOISE IN A WIND TUNNEL
JEAN PRIEUR (ONERA, Chatillon, France) (European Rotorcraft Forum, 16th, Glasgow, Scotland, Sept. 18-21, 1990) ONERA, TP no. 1990-123, 1990, 12 p. refs
(ONERA, TP NO. 1990-123)

Results are presented from high-speed impulsive noise (HSIN) tests of two model rotors, conducted in an acoustically-lined wind tunnel. While one of the rotors has rectangular planform blades, the other uses 30-deg sweptback tips of 'F30' configuration. The F30 tips are found to yield substantial noise reduction in the direction of maximum HSIN generation, in virtue of the delay of delocalization toward higher tip speeds; this, in turn, is a consequence of the suppression of transonic effects obtained by the sweptback tips. It is stressed that blade tip geometry may strongly influence noise radiation through the modification of shock surface geometries. O.C.

A91-12427*# Notre Dame Univ., IN.
ACOUSTIC RADIATION FROM LIFTING AIRFOILS IN COMPRESSIBLE SUBSONIC FLOW
HAFIZ M. ATASSI, SHANKAR SUBRAMANIAM (Notre Dame, University, IN), and JAMES R. SCOTT (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 21 p. refs
(Contract NAG3-732)
(AIAA PAPER 90-3911) Copyright

The far field acoustic radiation from a lifting airfoil in a three-dimensional gust is studied. The acoustic pressure is calculated using the Kirchhoff method, instead of using the classical acoustic analogy approach due to Lighthill. The pressure on the Kirchhoff surface is calculated using an existing numerical solution of the unsteady flow field. The far field acoustic pressure is calculated in terms of these values using Kirchhoff's formula. The method is validated against existing semi-analytical results for a flat plate. The method is then used to study the problem of an airfoil in a harmonic three-dimensional gust, for a wide range of Mach numbers. The effect of variation of the airfoil thickness and angle of attack on the acoustic far field is studied. The changes in the mechanism of sound generation and propagation due to the presence of steady loading and non-uniform mean flow are also studied. Author

A91-12428*# Arizona Univ., Tucson.
INFLUENCE OF AIRFOIL NOSE RADIUS ON SOUND GENERATED BY GUST INTERACTIONS
C. T. TSAI and E. J. KERSCHEN (Arizona, University, Tucson) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(Contract NAG3-357)
(AIAA PAPER 90-3912) Copyright

The sound radiated by interaction of a short wavelength gust (k much greater than 1) with a symmetric thin airfoil is analyzed. The theory is based on a linearization of the Euler equations about the subsonic mean flow past the airfoil. The sound generation mechanism is found to be concentrated in a local region surrounding the parabolic nose of the airfoil; the size of this local region scales on the gust wavelength. Airfoil thickness produces terms of relative order O(sq rt S) in the far field sound, where S is a Strouhal number based on the airfoil nose radius. At low Mach numbers, entropy gusts generate much less sound than

vorticity gusts. However, for O(1) Mach numbers and moderate values of S, entropy and vorticity gusts produce similar sound levels. Author

A91-12430*# *United Technologies Corp., Windsor Locks, CT.*
UNSTEADY AIRLOADING PANEL METHOD FOR PROP-FANS
D. B. HANSON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(Contract NAS3-23720)
(AIAA PAPER 90-3914) Copyright

An unsteady, linear, compressible, three dimensional lifting surface panel method is presented for use with propellers and prop-fans. Both gust and blade vibration problems can be treated. Derivation of the theory is based on the acceleration potential method and can be considered a generalization of the analogous wing theory to include rotation and multiple blades. As with the wing methods, the integral equation is discretized and solved by matrix inversion. Sample calculations are use to explore the difference between 2D and 3D results and the significance of unsteadiness in angular inflow calculations for propellers. It is shown at the once-per-revolution frequency of propellers, that quasi-steady methods should be adequate. At the high frequencies of interest in noise analysis, 2D strip methods give adequate results away from blade tips. For flutter, frequencies lie in an intermediate range where a full 3D unsteady technique seems to be required. Author

A91-12433#
APPLICATION OF COMPUTATIONAL METHODS IN AEROACOUSTICS
G. SENGUPTA, R. H. BURKHART, J. E. BUSSOLETTI, F. T. JOHNSON, R. G. MELVIN (Boeing Commercial Airplanes, Seattle, WA) et al. AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 14 p. refs
(AIAA PAPER 90-3917) Copyright

Several applications of a computational code for predicting acoustic scattering effects to problems in aeroacoustics are presented. First, the problem of sound generation by an incident vortical field interacting with an airfoil is considered by examining the analogous problem of the scattering of an incident plane wave by a flat plate. In the second application, the propagation of sound through ducts was examined, where there is an abrupt change in duct cross section. Finally, the scattering of propeller noise by an aircraft was considered, where the propeller noise was simulated by using a distribution of axial and circumferential dipoles. Preliminary predictions showed a significant degree of scattering, qualitatively similar to some wind-tunnel test data. I.S.

A91-12436#
NUMERICAL SIMULATION OF ACOUSTIC DIFFRACTION OF TWO-DIMENSIONAL RIGID BODIES IN ARBITRARY FLOWS
K. S. HUH (McDonnell Douglas Research Laboratories, Saint Louis, MO; MIT, Cambridge, MA), R. K. AGARWAL (McDonnell Douglas Research Laboratories, Saint Louis, MO), and S. E. WIDNALL (MIT, Cambridge, MA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 21 p. Research supported by McDonnell Douglas Corp. refs
(AIAA PAPER 90-3920) Copyright

Aeroacoustic perturbation quantities about various two-dimensional rigid bodies have been computed by solving the Euler equations in the complex domain. The governing equations are derived by linearizing the perturbation Euler equations, and by assuming a single frequency disturbance. A pseudo-time variable is introduced, and the entire set of equations is driven to convergence by an explicit, 5-stage Runge-Kutta, time-marching, finite volume scheme. A combination of radiation and characteristic boundary conditions is used in the far-field. Some comparisons are made with known analytic solutions and with previous investigators. Author

A91-12438*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ACTIVE CONTROL OF INTERIOR NOISE IN MODEL AIRCRAFT FUSELAGES USING PIEZOCERAMIC ACTUATORS
C. R. FULLER (Virginia Polytechnic Institute and State University, Blacksburg), C. H. HANSEN (Adelaide, University, Australia), R. J. SILCOX (NASA, Langley Research Center, Hampton, VA), and S. D. SNYDER AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(AIAA PAPER 90-3922) Copyright

Active control of interior noise in model aircraft fuselages using piezoceramic actuators is experimentally studied. The actuators are bonded directly to the structure and error information is taken from up to two microphones located in the interior acoustic field. The results demonstrate that global attenuation of the order of 10 to 15 dB of interior noise can be achieved with piezoceramic actuators, irrespective of whether the shell system is vibrating at an acoustic or structural resonant frequency. The work also proves that active control using vibration (moment) inputs works well when a floor simulating that of an aircraft is installed in the model. This result suggests that the technique will be successful in controlling interior noise in realistic aircraft structures. Author

A91-12440#
RECENT ADVANCES IN ACTIVE NOISE CONTROL
K. K. AHUJA (Georgia Institute of Technology, Atlanta) and J. C. STEVENS AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 14 p. Research supported by Georgia Institute of Technology. refs
(AIAA PAPER 90-3924) Copyright

Recent progress in the field of Active Noise Control is reviewed. The advent of the digital computer and subsequent speed and capacity improvements have made active noise control more practical and encouraged rapid advancement in research. Several surveys of research have been done in the past, so emphasis is placed on the newest and most innovative research. In particular, the advancement of research on active noise control during the decade of the eighties is reviewed. Author

A91-12442*# Douglas Aircraft Co., Inc., Long Beach, CA.
ESTIMATION OF THE TURBULENT BOUNDARY LAYER PRESSURE WAVENUMBER-FREQUENCY SPECTRUM USING A FIXED PROBE PAIR
GOPAL P. MATHUR and MARK R. CANNON (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(Contract NAS1-18037)
(AIAA PAPER 90-3926) Copyright

The turbulent boundary layer (TBL) pressure fluctuations represent a dominant source of aircraft interior noise during cruise. The wavenumber-frequency characteristics of the TBL pressure field become important when determining its coupling with the aircraft structure and the resulting sound radiation into the interior of the aircraft. A technique is presented to estimate the TBL pressure wavenumber-frequency spectrum using a fixed probe pair consisting of two microphones. Flight test data from the McDonnel Douglas Ultra High Bypass Demonstrator aircraft were used to estimate the TBL pressure wavenumber-frequency spectra. These data were compared with selected wall pressure prediction models based on the existing wind tunnel data. The estimated in-flight spectral levels for the Demonstrator aircraft were in good agreement with the TBL wall pressure prediction models in the medium wavenumber range. The estimated TBL wavenumber spectral levels were found to be on the higher side in the low wavenumber region when compared with the predicted levels. Author

A91-12444#
THERMOACOUSTICS OF UNSTEADY COMBUSTION
JAYESH M. MEHTA, P. MUNGUR, W. DODDS, D. BAHR (GE Aircraft Engines, Cincinnati, OH), and STEVE CLOUSER (U.S. Navy, Naval Air Propulsion Center, Trenton, NJ) AIAA, Aeroacoustics

Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 19 p. refs
(Contract N00140-87-C-9901)
(AIAA PAPER 90-3928)

A longitudinal mode of combustion instability has been studied experimentally and analytically for an advanced aircraft engine combustor system. For the tested configuration, a simple longitudinal acoustic mode consisting of a bulk mode in the inlet section and a traveling wave in the combustor sector section has been identified. The frequencies of oscillations covered a range of 150-380 Hz. A linear combustion instability prediction code was exercised to predict and interpret the acoustic behavior of the combustor. A salient feature of the analysis was the observation that the combustor inlet side reflection coefficient was found to have significant influence on combustor resonance frequency. The analysis was found to yield good agreement between computations and measured acoustic spectra and distributions of amplitudes and phase of the first longitudinal acoustic wave. Author

A91-12448*# *National Aeronautics and Space Administration.* Lewis Research Center, Cleveland, OH.
THE EFFECT OF SWIRL RECOVERY VANES ON THE CRUISE NOISE OF AN ADVANCED PROPELLER
JAMES H. DITTMAR (NASA, Lewis Research Center, Cleveland, OH) and DAVID G. HALL (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 16 p. refs
(AIAA PAPER 90-3932) Copyright

The SR-7A propeller was acoustically tested with and without downstream swirl recovery vanes to determine if any extra noise was caused by the interaction of the propeller wakes and vortices with these vanes. No additional noise was observed at the cruise condition over the angular range tested. The presence of the swirl recovery vanes did unload the propeller and some small peak noise reductions were observed from lower propeller loading noise. The propeller was also tested alone to investigate the behavior of the peak propeller noise with helical tip Mach number. As observed before on other propellers, the peak noise first rose with helical tip Mach number and then leveled off or decreased at higher helical tip Mach numbers. Detailed pressure-time histories indicate that a portion of the primary pressure pulse is progressively cancelled by a secondary pulse as the helical tip Mach number is increased. This cancellation appears to be responsible for the peak noise behavior at high helical tip Mach numbers. Author

A91-12449*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROACOUSTIC EFFECTS OF REDUCED AFT TIP SPEED AT CONSTANT THRUST FOR A MODEL COUNTERROTATION TURBOPROP AT TAKEOFF CONDITIONS
RICHARD P. WOODWARD and CHRISTOPHER E. HUGHES (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 19 p. refs
(AIAA PAPER 90-3933) Copyright

A model high-speed, advanced counterrotation propeller, F7/A7, was tested in the NASA Lewis Research Center's 9- by 15-foot anechoic wind tunnel at simulated takeoff and approach conditions of Mach 0.2. The propeller was operated in a baseline configuration with the forward and aft rotor blade setting angles (36.2deg and 35.4 deg) and forward and aft rotational speeds essentially equal. Two additional configurations were tested with the aft rotor at increased blade setting angles and the rotational speed reduced to achieve overall performance similar to that of the baseline configuration. The aft rotor blade angles were adjusted such that the thrust and power absorption for each rotor remained the same as for the baseline configuration. Acoustic data were taken with an axially translating microphone probe that was attached to the tunnel floor. Concurrent aerodynamic data were taken to define propeller operating conditions. The aft rotor fundamental tone was about 6 dB lower with the 36.2 deg and 38.4 deg blade setting angles, and about 9 dB lower with the 36.2 and 41.4 deg blade setting angles. Predicted noise reductions based on tip speed considerations were 5 and 9.5 dB, respectively, for the two altered blade setting angles. Author

A91-12450*# Lockheed Engineering and Sciences Co., Hampton, VA.
STATE-OF-THE-ART OF HIGH-SPEED PROPELLER NOISE PREDICTION - A MULTIDISCIPLINARY APPROACH AND COMPARISON WITH MEASURED DATA
MARK H. DUNN (Lockheed Engineering and Sciences Co., Hampton, VA) and F. FARASSAT (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 27 p. refs
(AIAA PAPER 90-3934) Copyright

The results of NASA's Propeller Test Assessment program involving extensive flight tests of a large-scale advanced propeller are presented. This has provided the opportunity to evaluate the current capability of advanced propeller noise prediction utilizing principally the exterior acoustic measurements for the prediction of exterior noise. The principal object of this study was to evaluate the state-of-the-art of noise prediction for advanced propellers utilizing the best available codes of the disciplines involved. The effects of blade deformation on the aerodynamics and noise of advanced propellers were also studied. It is concluded that blade deformation can appreciably influence propeller noise and aerodynamics, and that, in general, centrifugal and blade forces must both be included in the calculation of blade forces. It is noted that the present capability for free-field noise prediction of the first three harmonics for advanced propellers is fairly good. Detailed data and diagrams of the test results are presented. R.E.P.

A91-12451#
ANALYSIS OF THE PTA EXTERNAL NOISE DATA AND COMPARISON WITH PREDICTIONS
P. L. SPENCE (Lockheed Engineering and Sciences Co., Hampton, VA) and P. J. W. BLOCK (Vigyan Research Associates, Inc., Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 24 p. refs
(AIAA PAPER 90-3935) Copyright

Analyses of the Propfan Test Assessment external fuselage noise data and external boom data are presented. Data analysis was focused on an array of 45 microphones located on the external fuselage surface that are arranged into two line arrays, one around the fuselage at the plane of rotation, and the other along the fuselage side nearest to the propeller. A third group comprises a surface array of 39 microphones covering from top to bottom of the fuselage and from one diameter upstream to one diameter downstream of the plane of rotation. The data obtained from this surface array and the developed color contours of the noise intensity on the fuselage are presented. Also included are two flight test predictions and the comparison with measured data. R.E.P.

A91-12452#
PREDICTED VS. SCALE MODEL AND FLIGHT TEST UDF ENGINE NOISE
C. E. WHITFIELD and P. R. GLIEBE (GE Aircraft Engines, Cincinnati, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(AIAA PAPER 90-3936) Copyright

This paper presents an overview of the development of a frequency-domain, noncompact-source noise prediction model for the unducted fan (UDF) engine. A brief description of the acoustic modeling approach and basic equations employed is given, together with a summary of the aerodynamic characteristics utilized in the noise prediction model. Scale model test results obtained from both low-speed and high-speed wind tunnel measurements are compared with the prediction model, and comparisons of predicted vs measured flight noise characteristics for the full-scale engine are also discussed. Author

A91-12457#
SUPPRESSION OF FATIGUE INDUCING CAVITY ACOUSTIC MODES ON TURBO FAN ENGINES
R. H. BENNER (Rohr Industries, Inc., Chula Vista, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 9 p. refs
(AIAA PAPER 90-3941) Copyright

This paper discusses several methods of suppressing shear layer excitation of cavity acoustic modes on turbofan engines. The methods include the use of a Helmholtz resonator, reducing the cavity impingement length with vane-like dividers, and drawing the shear layer into the cavity. Empirical data and closed-form solutions were used to design baseline structures employed in each method. Full scale turbofan engine tests were used to measure their effectiveness. Each method significantly reduced the level to which cavity acoustic modes were excited by shear layer flow. Author

A91-12460*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BOUNDARY ELEMENT ANALYSIS OF SOUND SCATTERED BY A MOVING SURFACE
M. K. MYERS and J. S. HAUSMANN (George Washington University, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 13 p. refs
(Contract NCC1-14)
(AIAA PAPER 90-3944) Copyright

A solution for the acoustic field scattered from a uniformly moving rigid body in the presence of a harmonic incident source has been obtained using a boundary integral method. A derivation of the Kirchhoff formula given by Farassat and Myers (1988) for moving surfaces forms the basis for the analysis, and the development of a boundary integral method for the solution of scattering problems from moving rigid bodies is described. Finite elements are used in conjunction with the Galerkin method in order to solve the integral equation that results from the Kirchhoff formula when the observer point is placed on the moving body surface. Once appropriate surface field values are known they are inserted back into the formula in order to predict the field scattered off the body. Tests, including the so called superposition method, are carried out in order to validate the technique and to establish some confidence in its accuracy. Application of the superposition method to moving bodies is presented, and results of the two approaches are discussed. Sample calculations of scattering from a simple body are presented to illustrate the effects of variations in relevant parameters. L.K.S.

A91-12463*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REMOVING SPURIOUS REFLECTIONS FROM CFD SOLUTIONS BY USING THE COMPLEX CEPSTRUM
KRISTINE R. MEADOWS and JAY C. HARDIN (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(AIAA PAPER 90-3947) Copyright

The Complex Cepstrum is shown to remove spurious reflections from artificial boundaries in computational fluid dynamic (CFD) solutions. First, the Complex Cepstrum theory is presented. A model time sequence consisting of a direct signal and reflections is analyzed theoretically with the Complex Cepstrum, and it is shown that the direct signal uncontaminated by reflections may be recovered in the time domain. Next, the Complex Cepstrum is applied to one- and three-dimensional CFD solutions, and spurious reflections from the boundary conditions are removed. By eliminating spurious reflections introduced by artificial boundary conditions, the applicability of CFD methods to aeroacoustic problems is greatly enhanced. Author

A91-12464#
EXPERIMENTS ON THE AERODYNAMIC NOISE SOURCES IN CENTRIFUGAL TURBOMACHINERY
DENNIS K. MCLAUGHLIN, DONALD E. THOMPSON (Pennsylvania State University, University Park), and JONG-SOO CHOI AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(Contract N00014-87-K-0837)
(AIAA PAPER 90-3948) Copyright

Flow induced noise generation mechanisms in a centrifugal turbomachine are investigated in this study. To isolate the noise generation mechanisms of interest, a simplified discharge configuration was selected. The unsteady flowfield discharging from the rotating impeller has been measured with stationary hot-wire sensors. A space and time cross-correlation technique using two stationary hot-wire sensors was developed to simulate a rotating hot-wire measurement. The simulated auto-spectrum of the discharged velocity shows a similar pattern to that observed in the spectrum from an impeller mounted rotating pressure sensor. Experimental results demonstrate how the unsteady flow in the impeller passages, modulated by a mild rotating stall pattern, interacts with the trailing edge of the impeller blades, and generates noise. Author

A91-12466#
EXPERIMENTAL STUDY OF NOISE SOURCES AND ACOUSTIC PROPAGATION IN A TURBOFAN MODEL
S. LEWY, S. CANARD-CARUANA (ONERA, Chatillon, France), and J. JULLIARD (SNECMA, Moissy-Cramayel, France) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 16 p. Research supported by the Service Technique des Programmes Aeronautiques. refs
(AIAA PAPER 90-3950) Copyright

Experimental studies of the acoustic radiation of subsonic fans mainly due to blade and vane presure fluctuations were performed in the SNECMA 5C2 compressor anechoic facility. A brief description of the test rig is presented noting that the CA5 turbojet engine model fan has a diameter of 47 cm, 48 blades, and a nominal rotation speed of 12,600 rpm. The two chief experiments discussed are the measurement of blade and vane pressure fluctuations by thin-film transducers and the spinning mode analysis of the sound field propagating in the intake duct. Several examples of applications are discussed, and it is shown that an inflow control device, as expected, reduces the aerodynamic disturbances by about 10 dB. Rotor-stator interaction tones are determined by the modal analysis, and it is found that a duct lining with a length of one duct radius could give an insertion loss up to 20 dB in flight. L.K.S.

A91-12467#
ROTOR WAKE/STATOR INTERACTION NOISE-PREDICTIONS VERSUS DATA
D. A. TOPOL (Pratt and Whitney Group, East Hartford, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 14 p. refs
(AIAA PAPER 90-3951) Copyright

A rotor wake/stator interaction noise prediction method is presented and evaluated with fan rig and full-scale engine data. The noise prediction method uses a two-dimensional (2D) semi-empirical wake model and an analytical stator response function and noise calculation. The stator response function is a 2D strip theory which is linked to a noise calculation formulated in a constant area annular duct with mean axial flow. Comparisons are made with data from an Advanced Ducted Propeller (ADP) fan rig which is a next-generation turbofan engine design. A calibration of the prediction model is attempted using this rig data. The calibrated model is subsequently utilized to calculate and compare with noise test data from a 4.1-inch diameter fan rig and from a full-scale turbofan engine configuration. The results indicate the method has promise, but that further improvement is desirable. Author

A91-12468#
EXPERIMENTAL/THEORETICAL INVESTIGATION OF THE SOUND FIELD OF AN ISOLATED PROPELLER, INCLUDING ANGLE OF INCIDENCE EFFECTS
T. ZANDBERGEN (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), S. L. SARIN (Fokker Aircraft, Schiphol,

Netherlands), and R. P. DONNELLY (Dowty Aerospace Gloucester, Ltd., England) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 9 p. refs
(AIAA PAPER 90-3952) Copyright

A detailed experimental acoustic investigation was carried out in the German/Dutch low speed wind tunnel DNW on a 6 bladed 1:5 scale model propeller. Both the propeller near field and the far field were measured with axially traversing in-flow microphones and comparisons of test data and predictions have previously been reported for zero propeller incidence. Also included were tests under non-zero angle of attack, and sideslip angle, in order to obtain also data for a noise prediction method for propeller installation effects. In this report near field experimental data are compared with theoretical data, to show the capability of such a prediction scheme, and with the aim of indicating the behavior of the main parameters that are believed to control the noise changes with angle of incidence. Author

A91-12469*# Sverdrup Technology, Inc., Brook Park, OH.
NEAR-FIELD NOISE OF A SINGLE ROTATION PROPFAN AT AN ANGLE OF ATTACK
M. NALLASAMY, E. ENVIA (Sverdrup Technology, Inc., Brook Park, OH), B. J. CLARK, and J. F. GROENEWEG (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 18 p. refs
(AIAA PAPER 90-3953)

The near-field noise characteristics of a propfan operating at an angle of attack are examined utilizing the unsteady pressure field obtained from a three-dimensional Euler simulation of the propfan flowfield. The near-field noise is calculated employing three different procedures: a direct computation method in which the noise field is extracted directly from the Euler solution, and two acoustic-analogy-based frequency domain methods which utilize the computed unsteady pressure distribution on the propfan blades as the source term. The inflow angles considered are -0.4, 1.6, and 4.6 degrees. The results of the direct computation method and one of the frequency domain methods show qualitative agreement with measurements. They show that an increase in the inflow angle is accompanied by an increase in the sound pressure level at the outboard wing boom locations and a decrease in the sound pressure level at the (inboard) fuselage locations. The trends in the computed azimuthal directivities of the noise field also conform to the measured and expected results. Author

A91-12470*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF THE NOISE FROM A PROPELLER AT ANGLE OF ATTACK
EUGENE A. KREJSA (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 20 p. refs
(AIAA PAPER 90-3954) Copyright

An analysis is presented to predict the noise of a propeller at angle of attack. The analysis is an extension of that reported by Mani (1990) which predicted the change in noise due to angle of attack due to both unsteady loading and to azimuthal variation of the radiation efficiency of steady noise sources. Mani's analysis, however, was limited to small angles of attack. The analysis reported herein removes this small angle limitation. Results from the analysis are compared with the data of Woodward (1987, 1988), for a single rotation propeller and for a counter rotating propeller. The comparison shows that including the effect of angle of attack on the steady noise sources significantly improves the agreement with data. Including higher order effects of angle of attack, while changing the predicted noise at far forward and aft angles, has little effect near the propeller plane. Author

A91-12471#
NOISE RADIATION OF PROPELLER LOADING SOURCES WITH ANGULAR INFLOW
D. B. HANSON (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 21 p. Research supported by United Technologies Corp. refs
(AIAA PAPER 90-3955) Copyright

Far field propeller loading noise equations are developed using the free-space Green function for the convected wave equation to represent both axial and transverse Mach number components. Inflow angularity influences noise in two distinct ways. First, loading is modulated causing generation of more efficient radiation modes. Second, the radiation modes themselves are modified, causing a further noise increase. The first effect is well known; the second effect has only recently been recognized and is the subject of this paper. The noise formulas exhibit the same spinning mode behavior seen in previous analyses but with higher levels radiated into the crossflow. Since the modes are no longer purely spinning, the term 'wobbling mode' has been coined to describe their behavior. This paper explores the radiation formulas in detail, compares them with related theoretical treatments, and presents some calculations that explore the magnitude of the effect. Author

A91-12475*# AeroChem Research Labs., Inc., Princeton, NJ.
TIME-DEPENDENT JET FLOW AND NOISE COMPUTATIONS
C. H. BERMAN (AeroChem Research Laboratories, Inc., Princeton, NJ), J. I. RAMOS (Carnegie-Mellon University, Pittsburgh, PA), G. E. KARNIADAKIS, and S. A. ORSZAG (Princeton University, NJ) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(Contract NAS3-25829; NAS1-18849)
(AIAA PAPER 90-3961) Copyright

Methods for computing jet turbulence noise based on the time-dependent solution of Lighthill's (1952) differential equation are demonstrated. A key element in this approach is a flow code for solving the time-dependent Navier-Stokes equations at relatively high Reynolds numbers. Jet flow results at Re = 10,000 are presented here. This code combines a computationally efficient spectral element technique and a new self-consistent turbulence subgrid model to supply values for Lighthill's turbulence noise source tensor. Author

A91-12476#
INSTABILITY CHARACTERISTICS OF A LOW ASPECT RATIO RECTANGULAR JET
C. SHIH, S. GOGINENI, and A. KROTHAPALLI (Florida Agricultural and Mechanical University; Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(AIAA PAPER 90-3962) Copyright

The instability characteristics of a low (4 to 1) aspect ratio rectangular jet were investigated at exit Mach numbers ranging from low subsonic to moderate supersonic (between 0.03 and 1.5). It was found that the variation of the most amplified instability mode (preferred mode) in the jet exhibits four distinct regions. These were identified (according to the arrangement of the flow structures with respect to the jet centerline) as (1) region I (from 1 to 20 m/sec), in which the flow instability is dominated by the vortex merging interactions in the shear layer; (2) region II (Mach numbers between 0.1 and 0.6), in which antisymmetric flow structures dominate the flow development; (3) region III (Mach numbers between 0.6 and 0.85), where both antisymmetric and symmetric structures exist; and (4) region IV (Mach numbers higher than 1.2), a symmetric mode region. I.S.

A91-12477*# University of Southern California, Los Angeles.
COHERENT STRUCTURE INDUCED PRESSURE FLUCTUATIONS IN AN ELLIPTIC JET
S. SCHRECK and C. M. HO (Southern California, University, Los Angeles, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 6 p. refs
(Contract NAG1-1096)
(AIAA PAPER 90-3963) Copyright

The fluctuating pressure near an M = 0.5 elliptic jet was examined. Layered structures of the pressure field were found. Just outside of the jet edge, the pressure is mainly produced by

the passing vortices. A short distance away from this layer, the pressure fluctuations originating from the end of the potential core become dominant and are the source of the far field noise.
Author

A91-12479*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NOISE TRANSMISSION CHARACTERISTICS OF A LARGE SCALE COMPOSITE FUSELAGE MODEL
TODD B. BEYER and RICHARD J. SILCOX (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(AIAA PAPER 90-3965) Copyright

Results from an experimental test undertaken to study the basic noise transmission characteristics of a realistic, built-up composite fuselage model are presented. The floor-equipped stiffened composite cylinder was exposed to a number of different exterior noise source configurations in a large anechoic chamber. These exterior source configurations included two point sources located in the same plane on opposite sides of the cylinder, a single point source and a propeller simulator. The results indicate that the interior source field is affected strongly by exterior noise source phasing. Sidewall treatment is seen to reduce the overall interior sound pressure levels and dampen dominant acoustic resonances so that other acoustic modes can affect interior noise distribution.
R.E.P.

A91-12480#
STRUCTURE-BORNE NOISE TRANSMISSION IN THE PROPFAN TEST ASSESSMENT AIRCRAFT
JAMES F. UNRUH (Southwest Research Institute, San Antonio, TX) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 7 p. refs
(AIAA PAPER 90-3966) Copyright

Estimates of the level of structure-borne noise transmission in the Propfan Test Assessment (PTA) aircraft were carried out for the first three blade passage frequencies. The procedure used combined the frequency response functions of cabin sound pressure level to wing strain response obtained during ground test of the PTA aircraft with in-flight measured wing strain response data. The estimated structure-borne noise levels varied from 64 to 84 dB showing very little dependence on engine/propeller power, flight altitude, or flight Mach number. In general, the bare cabin in-flight noise levels decreased with increasing propeller tone giving rise to a plausible structure-borne noise transmission problem at the higher blade passage tones. Without knowledge of the effects of a high insertion loss side wall treatment on structure-borne noise transmission of the bare cabin no quantitative conclusions could be made on the level of structure-borne noise transmission in a treated production aircraft.
Author

A91-12482*# Douglas Aircraft Co., Inc., Long Beach, CA.
THE USE OF SPATIAL COHERENCE TECHNIQUES FOR IDENTIFYING NOISE TRANSMISSION PATHS ON THE MDC-UHB DEMONSTRATOR AIRCRAFT
BOI N. TRAN and MYLES A. SIMPSON (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(Contract NAS1-18037)
(AIAA PAPER 90-3968) Copyright

Application of partial coherence techniques to determination of the transmission paths of sound into an airplane cabin interior has been studied. Accurate quantitative information on the dominant paths of acoustic energy transmission can be obtained with this technique as well as the relative contributions from airborne and structure-borne paths. This information is useful in making design changes in the fuselage to reduce the interior cabin noise. The techniques are successfully applied to noise and vibration data collected during flight tests of the McDonnel Douglas Ultra-High Bypass Demonstrator aircraft, and these results are compared with other data measured during the flight program.
Author

A91-12483#
AN EXPERIMENTAL TECHNIQUE OF SEPARATING AIRBORNE AND STRUCTURE-BORNE NOISE USING WAVENUMBER-FREQUENCY SPECTRUM
GOPAL P. MATHUR, BRYCE K. GARDNER, JAMES E. PHILLIPS, and PAUL L. BURGE (Douglas Aircraft Co., Long Beach, CA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p. refs
(AIAA PAPER 90-3969) Copyright

An experimental technique for separating airborne and structure-borne noise components using the wavenumber-frequency spectral mapping of the radiated sound field is described. In the experiments, the wavenumber-frequency spectra of the vibrational response and the radiated sound field of a flat plate subjected to a uniform acoustic field and a point mechanical input were determined using modal expansion and boundary element methods. It is shown that the wavenumber-frequency spectra of the vibration response and sound radiation from the plate reveal the basic mechanisms of airborne and structure-borne sound radiation, making it possible to separate the two noise components.
I.S.

A91-12484*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOME FAR-FIELD ACOUSTICS CHARACTERISTICS OF THE XV-15 TILT-ROTOR AIRCRAFT
ROBERT A. GOLUB, DAVID A. CONNER (NASA, Langley Research Center, Hampton, VA), LAWRENCE E. BECKER, C. KENDALL RUTLEDGE, and RITA A. SMITH (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 15 p. refs
(AIAA PAPER 90-3971) Copyright

Far-field acoustics tests have been conducted on an instrumented XV-15 tilt-rotor aircraft. The purpose of these acoustic measurements was to create an encompassing, high confidence (90 percent), and accurate (-1.4/ +1/8 dB theoretical confidence interval) far-field acousitcs data base to validate ROTONET and other current rotorcraft noise prediction computer codes. This paper describes the flight techniques used, with emphasis on the care taken to obtain high-quality far-field acoustic data. The quality and extensiveness of the data base collected are shown by presentation of ground acoustic contours for level flyovers for the airplane flight mode and for several forward velocities and nacelle tilts for the transition mode and helicopter flight mode. Acoustic pressure time-histories and fully analyzed ensemble averaged far-field data results (spectra) are shown for each of the ground contour cases.
Author

A91-12485#
NOISE MECHANISMS OF TRANSONIC VORTEX AIRFOIL INTERACTION
H.-M. LENT, K. F. LOEHR, G. E. A. MEIER, K. J. MUELLER, U. SCHIEVELBUSCH (Max-Planck-Institut fuer Stroemungsforschung, Goettingen, Federal Republic of Germany) et al. AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(AIAA PAPER 90-3972) Copyright

Experiments on the compressible vortex-airfoil interaction were performed in a compressible flow. For this investigation two different experimental setups were used to obtain a two-dimensional interaction which was mainly observed with interferometric techniques. During the interaction two mechanisms for the generation of soundwaves were found. For both mechanisms simple models were constructed which can explain the onset and particularly the strength of these waves. Besides the soundgeneration, viscosity effects of the flow were observed such as separation of the flow at the leading edge and secondary vortices at the shoulder of the airfoil. But these effects seem not to govern the sound emission.
Author

A91-12486*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE IDENTIFICATION OF HELICOPTER NOISE USING A NEURAL NETWORK
RANDOLPH H. CABELL, CHRIS R. FULLER, and WALTER F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(Contract NAS1-18471)
(AIAA PAPER 90-3973) Copyright

Experiments were carried out to demonstrate the ability of an artificial neural network (ANN) system to distinguish between the noise of two helicopters. The ANN is taught to identify helicopters by using two types of features: one that is associated with the ratio of the main-rotor to tail-rotor blade passage frequency (BPF), and the ohter that describes the distribution of peaks in the main-rotor spectrum, which is independent of the tail-rotor. It is shown that the ability of the ANN to identify helicopters is comparable to that of a conventional recognition system using the ratio of the main-rotor BPF to the tail-rotor BPF (when both the main- and the tail-rotor noise are present), but the performoance of ANN exceeds the conventional-method performance when the tail-rotor noise is absent. In addition, the results of ANN can be obtained as a function of propagation distance. I.S.

A91-12490#
THE ROLE OF LEADING EDGE VORTEX FLOWS IN PROP-FAN INTERACTION NOISE
J. C. SIMONICH, D. C. MCCORMICK, and P. L. LAVRICH (United Technologies Research Center, East Hartford, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. Research supported by the United Technologies Corp. refs
(AIAA PAPER 90-3977) Copyright

A simulation study to investigate the interaction mechanisms associated with wakes from both aft-swept and forward-swept vanes incident on rotating prop-fan blades is presented. The forward-swept vane caused the leading edge vortex and an associated core velocity defect to move inboard toward the hub and away from the high speed tip region of the prop-fan. The aft-swept vane, however, directed the leading edge vortex out towards the tip, and led a large axial velocity disturbance to be swept toward the tip region of the prop-fan. Noise measurements show that the forward-swept vane wakes generated relatively lower interaction noise than the aft-swept vane wakes at equivalent vane loadings. It is suggested that by reducing the sweep, or changing the spanwise loading on the blades, it may be possible to control the magnitude and/or location of the velocity defect that is associated with the leading edge vortex. R.E.P.

A91-12491#
VORTEX STRUCTURE OF WAKES BEHIND AN ADVANCED PROPELLER AT TAKEOFF LOAD CONDITIONS
PHILIP L. LAVRICH, DUANE C. MCCORMICK (United Technologies Research Center, East Hartford, CT), and DAVID J. PARZYCH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 18 p. Research supported by the United Technologies Corp. refs
(AIAA PAPER 90-3978) Copyright

This paper examines the vortical structure of the wake downstream of a single advanced propeller Prop-Fan rotor at simulated takeoff conditions. Flow visualization and three component velocity measurements were performed. The wake was found to consist of a vortical structure consisting of merged leading edge and tip vortex as well as inboard viscous wakes. It is likely that the leading edge vortex core on the Prop-Fan blade is burst, leading to a large core size, reduced tangential velocities, and large streamwise velocity defect. A semi-empirical model is presented which was formulated to predict vortex core velocities. This model made significant improvements to wake predictions of highly loaded, swept airfoils. Author

A91-12492#
A MODAL EVALUATION OF NOISE GENERATED BY THE FRONT ROTOR OF A COUNTER-ROTATING PROP-FAN
DAVID J. PARZYCH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 6 p. Research supported by the United Technologies Corp. refs
(AIAA PAPER 90-3979) Copyright

The noise generated by the upstream rotor of a counterrotating propfan (CRP) was estimated using a 10 x 8 bladed 22-in CRP model installed in a wind tunnel. The tests were designed specifically to isolate the contribution of noise produced by the front or the rear rotors of the CRP. In the tests, the front rotor's blade angle was held constant, and the rear rotor's blade angle was varied; this arrangement provided a constant source of wakes from the front rotor, but allowed the upstream potential field associated with the rear rotor to vary. The results show that a significant amount of aerodynamic interacton noise is produced by the front rotor of a CRP, due to the upstream potential field of the rear rotor. I.S.

A91-12493#
THE SCREECH OF ROUND CHOKED JETS, REVISITED
ALAN POWELL (Houston, University, TX), Y. UMEDA, and R. ISHII (Kyoto University, Japan) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 5 p. Research supported by the Texas Advanced Research Program and University of Houston. refs
(AIAA PAPER 90-3980) Copyright

The screech modes of round choked jets issued from a convergent 1-cm-diam circular nozzle are studied using two microphones, located at a radius of 7.7. cm upstream of the face of the nozzle: one kept in a fixed position, and the other rotated about the axis in 15-deg increments up to 180 deg relative to the first one. The signal outputs were recorded in the 100 Hz to 100 kHz band and were analyzed using a digital correlator and an analyzer. Results of correlation measurements showed that, as the pressure ratio increased, the unstable screech modes of oscillation of round jets were toroidal (lateral), toroidal again, sinuous, helical; and then sinuous again; while one mode dominates, another one may occur weakly and simultaneously, its frequency variation being a smooth continuation of that when it dominates. The frequency of the dominant helical mode was found to be greater than that of the concurrent secondary or adjacent dominant sinuous modes. I.S.

A91-12495*# Georgia Inst. of Tech., Atlanta.
AN EVALUATION OF VARIOUS CONCEPTS OF REDUCING SUPERSONIC JET NOISE
K. K. AHUJA (Georgia Institute of Technology, Atlanta), J. P. MANES, K. C. MASSEY, and A. B. CALLOWAY AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 22 p. refs
(Contract NAG3-1066)
(AIAA PAPER 90-3982) Copyright

Acoustic and flow visualization data from nozzles mounted on the same facility were acquired, and a total of 10 different concepts of jet noise suppression were evaluated relative to one another and also a round nozzle. All nozzles had the same exit area. The suppressors included noncircular shapes; nozzles fitted with notches, tabs, and ejectors; and coaxial rectangular nozzles. Narrow-band noise data were acquired by a microphone located in the plane of the jet exit. In general, it is found that, for a constant exit area, the round nozzle is the noisiest. Just about any modification of this round nozzle around its periphery reduces the broadband shock-associated noise and, in most instances; modifies the screech frequency and levels. Coaxial rectangular nozzles, nozzles fitted with two tabs and operated with ejectors, and a rectangular C-D nozzles with perforated walls are identified to be the most promising concepts worthy of further investigation. Author

A91-12496*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NOISE MEASUREMENTS FROM AN EJECTOR SUPPRESSOR NOZZLE IN THE NASA LEWIS 9- BY 15-FOOT LOW SPEED WIND TUNNEL
EUGENE A. KREJSA, BETH A. COOPER (NASA, Lewis Research Center, Cleveland, OH), DAVID G. HALL, and ABBAS KHAVARAN (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 61 p. refs
(AIAA PAPER 90-3983) Copyright

Acoustic results are presented on nozzle test experiments conducted in the NASA Lewis 9 x 15-ft anechoic wind tunnel on a 'hypermix' nozzle concept, a two-dimensional lobed mixer nozzle followed by a short ejector section designed to promote rapid mixing of the nozzle flow with the flow induced by the ejector. Acoustic and aerodyanmic measurements were carried out to determine the amount of ejector pumping, the degree of mixing, and the noise reduction achieved. Spectra from various nozzle configurations were compared to show the effect of the nozzle geometry on nozzle-alone noise, the benefit of adding an ejector to the mixer nozzles, and the effect of the ejector geometry on ejector/suppressor noise level. I.S.

A91-12502*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SOME AEROACOUSTIC AND AERODYNAMIC APPLICATIONS OF THE THEORY OF NONEQUILIBRIUM THERMODYNAMICS
W. CLIFTON HORNE, CHARLES A. SMITH (NASA, Ames Research Center, Moffett Field, CA), and KRISHNAMURTY KARAMCHETI (Florida State University, Tallahassee) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 22 p. refs
(AIAA PAPER 90-3989) Copyright

An exact equation is derived for the dissipation function of a homogeneous, isotropic, Newtonian fluid, with terms associated with irreversible compression or expansion, wave radiation, and the square of the vorticity. This and other forms of the dissipation function are used to identify simple flows, such as incompressible channel flow, the potential vortex with rotational core, and incompressible, irrotational flow as minimally dissipative distributions. A comparison of the hydrodynamic and thermodynamic stability characteristics of a parallel shear flow suggests that an association exists between flow stability and the variation of net dissipation with disturbance amplitude, and that nonlinear effects, such as bounded disturbance amplitude, may be examined from a thermodynamic basis. Author

A91-12504*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SOUND TRANSMISSION THROUGH A HIGH-TEMPERATURE ACOUSTIC PROBE TUBE
TONY L. PARROTT and WILLIAM E. ZORUMSKI (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-3991)

An investigation was conducted of acoustic transmission through a tube subjected to an intense thermal gradient along its axis. The results are of interest in the interpretation of acoustic data from probe tube configurations designed to measure fluctuating pressures in high temperature environments. The measured transfer function across a localized heated region in the tube was compared to a computed transfer function based on a theoretical analysis of propagation through strong temperature gradients. Over the frequency range 0.4 kHz to 6.0 kHz, generally good agreement was obtained between the measured and calculated attenuation across the heated region with some discrepancy occurring at the attenuation minima. Agreement between measured and calculated phase difference was excellent to within the measurement resolution. Author

A91-12505*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
IDENTIFICATION OF AEROSPACE ACOUSTIC SOURCES USING SPARSE DISTRIBUTED ASSOCIATIVE MEMORY
E. A. SCOTT, C. R. FULLER, and W. F. O'BRIEN (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(Contract NAG1-762)
(AIAA PAPER 90-3992) Copyright

A pattern recognition system has been developed to classify five different aerospace acoustic sources. In this paper the performance of two new classifiers, an associative memory classifier and a neural network classifier, is compared to the performance of a previously designed system. Sources are classified using features calculated from the time and frequency domain. Each classifier undergoes a training period where it learns to classify sources correctly based on a set of known sources. After training the classifier is tested with unknown sources. Results show that over 96 percent of sources were identified correctly with the new associative memory classifier. The neural network classifier identified over 81 percent of the sources correctly. Author

A91-12506#
RADIATION INTEGRALS FOR SOUND GENERATION BY THE LIGHTHILL QUADRUPOLES IN PROPELLER ACOUSTICS
N. PEAKE and D. G. CRIGHTON (Cambridge, University, England) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 14 p. Research supported by Rolls-Royce, PLC. refs
(AIAA PAPER 90-3993) Copyright

This paper considers a number of features of Hanson's frequency domain radiation integrals for propeller acoustics. First, the use of the thin blade approximation in the surface noise source, a common feature of Hanson's work, involving a repositioning of the surface terms onto a mean plane, is considered in detail, and shown to introduce errors into the higher derivatives of the real time wave form. Second, a corrected version of Hanson's integral for the Lighthill quadrupole radiation is presented. Finally, asymptotic analysis is applied and various features of the new surface source integrals are revealed. Author

A91-12507#
DIFFRACTION PATTERNS IN THE ACOUSTIC FIELD OF A PROPELLER
C. J. CHAPMAN (Cambridge, University, England) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. Research supported by the Royal Aircraft Establishment. refs
(AIAA PAPER 90-3994) Copyright

Certain aspects of high-speed propeller acoustics can be readily understood by means of the classical theory of diffraction. An account is given of the main features of this theory by considering three illustrative examples from optics and acoustics; it is then shown how the theory applies to multibladed propellers and the high harmonics of any propeller. The stationary phase method is ideal for deriving asymptotic formulas for such acoustic fields, and leads to a decomposition of both the near and far field into different types of quiet and loud zones. Author

A91-12509*# Texas A&M Univ., College Station.
ON THE PREDICTION OF FAR FIELD COMPUTATIONAL AEROACOUSTICS OF ADVANCED PROPELLERS
STEPHEN M. JAEGER (McDonnell Douglas Technologies, Inc., San Diego, CA) and KENNETH D. KORKAN (Texas A & M University, College Station) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(Contract NAG3-354)
(AIAA PAPER 90-3996) Copyright

A numerical method for determining the acoustic far field generated by a high-speed subsonic aircraft propeller was developed. The approach used in this method was to generate

the entire three-dimensional pressure field about the propeller (using an Euler flowfield solver) and then to apply a solution of the wave equation on a cylindrical surface enveloping the propeller. The method is applied to generate the three-dimensional flowfield between two blades of an advanced propeller. The results are compared with experimental data obtained in a wind-tunnel test at a Mach number of 0.6. I.S.

A91-12514*# Mississippi Univ., University.
COMPARISON OF SHOCK WAVE RISE TIME PREDICTION TECHNIQUES
RICHARD RASPET and HENRY E. BASS (Mississippi, University, University) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 5 p. Research supported by NASA.
(AIAA PAPER 90-4001) Copyright

Two techniques for predicting sonic-boom rise times are described, and the values of the rise time (defined as the time required for the shock front to go from 10 percent to 90 percent of the maximum overpressure) predicted when using the two approaches are compared. The results are applied to the prediction of the rise time from two hypothetical supersonic transport aircraft. In both cases, the rise time predicted at the ground was much greater than that predicted for a conventional SST. I.S.

A91-12515*# Stanford Univ., CA.
THE SONIC BOOM OF AN OBLIQUE FLYING WING
ILAN KROO (Stanford University, CA) and ALEX VAN DER VELDEN AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. Research supported by NASA. refs
(AIAA PAPER 90-4002) Copyright

An analysis of sonic boom characteristics of an oblique flying wing is presented. The wing, represented by a slewed lift and area-distribution as well as a panel geometry, promises a reduction of sonic boom signature. For every azimuth angle these distributions are represented by an equivalent body. The near-field pressure signature is determined by using the Whitham F-function with a correction to account for nonlinear wave propagation. The geometric asymmetry leads to an asymmetrical sonic boom beneath the flight track with bow shocks between 1.0 and 1.5 PSF. Due to favorable volume-lift interference the aft shock has only half the amplitude of the bow shock. A fast numerical method is described to calculate the perceived loudness. R.E.P.

A91-12516#
SONIC BOOM FOCAL ZONES DUE TO TACTICAL AIRCRAFT MANEUVERS
KENNETH J. PLOTKIN (Wyle Laboratories, Inc., Arlington, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(Contract F49642-83-C-0223)
(AIAA PAPER 90-4003) Copyright

A study has been conducted of the focal zone 'superbooms' associated with tactical maneuvers of military supersonic aircraft. Focal zone footprints were computed for 21 tactical maneuvers: two for the SR-71 and 19 for fighters engaged in air combat maneuver (ACM) training. These footprints provide quantitative results which may be used for environmental planning. A key finding of this study is that focus factors and footprint areas for high-g fighter maneuvers are substantially smaller than those for gentle maneuvers associated with larger aircraft. Author

A91-12517#
THE MEASUREMENT OF SONIC BOOM WAVEFORMS AND PROPAGATION CHARACTERISTICS - TECHNIQUES AND CHALLENGES
ALFRED J. BEDARD, JR. (NOAA, Wave Propagation Laboratory, Boulder, CO) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. refs
(AIAA PAPER 90-4004)

The measurement of sonic boom waveforms in a turbulent atmosphere with complex nonstationary profiles and three-dimensional structures of temperature, wind, and humidity presents a difficult challenge. Representative measurements are critical for the verification of not only numerical predictive models but also of concepts for sonic boom alleviation. Variations in aircraft flight paths and speed as well as organized atmospheric structures in the acoustic propagation path further complicate this measurement problem. This paper reviews past experimental approaches, pointing out measurement needs; suggests possibilities in the form of new instruments, processing, and concepts that could be applied; and indicates the opportunities that exist or are being planned for facilities and networks that could provide data for initializing predictive models on a nationwide basis, or provide sites for field experiments. Author

A91-12519#
CONTROLLING PLUME DEFLECTION BY ACOUSTIC EXCITATION - AN EXPERIMENTAL DEMONSTRATION
K. K. AHUJA (Georgia Institute of Technology, Atlanta) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. Research supported by Georgia Institute of Technology and Lockheed Corp. refs
(AIAA PAPER 90-4006) Copyright

Effect of imposing an external sound field on a Coanda jet was investigated experimentally. It was found that the exhaust angle of a Coanda plume can be varied by changing the level of excitation. Limited experiments were also performed in a wind tunnel to study the effects of flight simulation on plume deflection controllability by sound using a hollow airfoil fitted with a Coanda jet. Pressure coefficients are measured over this airfoil with and without acoustic excitation of the Coanda Jet. This exploratory study provided a number of new ideas for future work for controlling flow over curved surfaces. Author

A91-12520*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TRANSITION CONTROL OF INSTABILITY WAVES OVER A FLEXIBLE SURFACE IN THE PRESENCE OF AN ACOUSTIC FIELD
L. MAESTRELLO (NASA, Langley Research Center, Hampton, VA) and F. W. GROSVELD (NASA, Langley Research Center; Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 9 p. refs
(AIAA PAPER 90-4008) Copyright

Experimental results are presented which demonstrate the coupling of a laminar boundary layer flow with a typical flexible aircraft panel. It is shown that the boundary layer induces plate oscillations which, in turn, perturb the flow at the same frequencies. This feedback mechanism is an inherent property of laminar boundary layer flow passing over a flexible plate. As a result, the flexibility of the plate becomes a source of early transition. The laminar boundary layer at the leading edge of the plate reacts to small, upstream, unsteady disturbances due to a streamwise pressure gradient. The experiments demonstrate that a nominal sound pressure incident at the leading edge triggers early transition. It is shown that transition can be delayed by activating a heat source at the leading edge of the plate which results in downstream cooling. Author

A91-12522#
FORCING LEVEL EFFECT OF INTERNAL ACOUSTIC EXCITATION ON THE IMPROVEMENT OF AIRFOIL PERFORMANCE
F. B. HSIAO (National Cheng Kung University, Tainan, Republic of China), R. C. CHANG (CSIST, Aeronautical Research Laboratory, Taichung, Republic of China), and R. N. SHYU AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 9 p. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-79-0210-D006-03)
(AIAA PAPER 90-4010) Copyright

The effects of internal acoustic excitation on the leading edge separated boundary layers and the aerodynamic performance over an airfoil of NACA 63(3)-018 cross section are examined as a function of excitation amplitude and frequency. Tests are conducted in an open-type suction wind tunnel at the Reynolds number of

300,000. Experimental results indicate that the flow separation is suppressed at the angles lower than the stalled angle by using small-amplitude excitation with the frequency near the shear layer instability frequency. As the forcing level is increased to some extent, the velocity fluctuations produced by the unsteady pulsing of fluid are demonstrated to be the primary governing parameter for modifying the separated flow properties. The data also show that the effective forcing frequency extends over a wider range as compared to the lower level excitation. Author

A91-12525*# Florida Atlantic Univ., Boca Raton.
A RAY-ACOUSTICS APPROACH TO FUSELAGE SCATTERING OF ROTOR NOISE
NOUREDDINE ATALLA and STEWART A. L. GLEGG (Florida Atlantic University, Boca Raton) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(Contract NAG1-715)
(AIAA PAPER 90-4013) Copyright

A ray acoustics approach to fuselage scattering of rotor noise is considered. The method is based on a combination of classical geometrical acoustics and the paraxial ray approximation. The method can handle scattering by objects of arbitrary shapes and can be applied in an inhomogeneous moving medium. Applications to aeroacoustics include the scattering of blade vortex interaction (BVI) pulses by rigid scattering objects. The BVI is modeled by a rotating impulsive point force. It has been found that scattering effects of rotating sources cannot be ignored. Flow has also been found to cause a modification and displacement of the directivity pattern and the shadow zones behind scatterers. Author

A91-12526#
NOISE CHARACTERISTICS OF THE JAPAN'S EXPERIMENTAL POWERED LIFT STOL AIRCRAFT
MASATAKA MAITA, KATSUMI TAKEDA (National Aerospace Laboratory, Chofu, Japan), MASAKI SAITOH, and KEN OHSUMI (Kawasaki Heavy Industries, Ltd., Kakamigahara, Japan) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 11 p. refs
(AIAA PAPER 90-4014) Copyright

The extensive flight noise data available for the Quiet Short Take Off and Landing Experimental Aircraft (QSTOL), ASKA, are summarized. Flight test results, compared with prior subscale model/theoretical data, have been used to provide and refine the powered-lift aircraft noise prediction method, which was extended to generate noise exposure level (footprints) and predict noise abatement flight operation. It is argued that estimated contours of equal noise exposure level shows that STOL operation has potential for reducing noise footprints, as compared with conventional aircraft. Schematic diagrams are provided of the noise data instrumentation and data processing system, and a noise data analysis program flow chart is presented. L.K.S.

A91-12528*# Illinois Inst. of Tech., Chicago.
AEROACOUSTIC ENVIRONMENT OF AN ADVANCED STOVL AIRCRAFT IN HOVER
RICHARD W. WLEZIEN (Illinois Institute of Technology, Chicago) and PETER J. FERRARO (McDonnell Aircraft Co., Saint Louis, MO) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 12 p. refs
(Contract NAS1-18745)
(AIAA PAPER 90-4016) Copyright

The near-field aeroacoustic environment of a 6.02 pct scale advanced short takeoff and vertical landing aircraft is investigated in proximity to a simulated ground plane. The screech and impingement-tone characteristics of twin supersonic round and rectangular plumes are shown to be highly dependent on nozzle geometry and height above the ground plane. Shadowgraph and laser-sheet flow visualization are used to clarify the flowfield mechanisms responsible for time-dependent loads due to screech, impingement tones, and unsteady impingement of the upwash on the fuselage undersurface. Detailed dynamic pressure measurements from an array of transducers on the fuselage confirms that fountain impingement is responsible for the greatest unsteady loading. Author

A91-12533*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
UNSTEADY BLADE PRESSURE MEASUREMENTS FOR THE SR-7A PROPELLER AT CRUISE CONDITIONS
L. J. HEIDELBERG (NASA, Lewis Research Center, Cleveland, OH) and M. NALLASAMY (NASA, Lewis Research Center; Sverdrup Technology, Inc., Brook Park, OH) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 16 p. refs
(AIAA PAPER 90-4022) Copyright

The unsteady blade surface pressures were measured on the SR-7A propeller. The freestream Mach number, inflow angle, and advance ratio were varied while measurements were made at nine blade stations. At a freestream Mach number of 0.8, the data in terms of unsteady pressure coefficient versus azimuth angle are compared to an unsteady three-dimensional Euler solution, yielding very encouraging results. The code predicts the shape (phase) of the waveform very well, while the magnitude is over-predicted in many cases. At tunnel Mach numbers below 0.6, an unusually large response on the suction surface at 0.15 chord and 0.88 radius was observed. The behavior of this response suggests the presence of a leading-edge vortex. Author

A91-12534#
INSTALLATION EFFECTS ON COUNTER ROTATING PROPELLER NOISE
B. N. SHIVASHANKARA, D. P. JOHNSON, and R. D. CUTHBERTSON (Boeing Commercial Airplanes, Seattle, WA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 8 p.
(AIAA PAPER 90-4023) Copyright

A test of a scale model of the Ultra-high bypass open rotor engine (the UDF engine) at a typical takeoff power condition was conducted at the German-Dutch wind tunnel (DNW) in Holland in order to determine the possible noise increase of the engine installation on the aft end of the fuselage. The effects of pylon, aft-body, and empennage were examined individually and in combination. For most of the configurations the number of blades in the forward rotor row was different from that in the aft rotor row so that it was possible to distinguish steady and interaction tones in the narrow band spectra. Results were taken at a tunnel Mach number of 0.22 and at an inflow sideline distance of 8.16 ft. Test results include evidence that the addition of the pylon upstream of the propulsor increases the blade passage frequency by as much as 10-12 dB but has a negligible effect on interaction tones. Data taken at the Boeing Transonic Wind Tunnel facility agreed reasonably well with those taken at DNW. L.K.S.

A91-12540*# Pennsylvania State Univ., University Park.
WEAK SHOCK PROPAGATION THROUGH A TURBULENT ATMOSPHERE
ALLAN D. PIERCE and VICTOR W. SPARROW (Pennsylvania State University, University Park) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 10 p. Research supported by NASA. refs
(AIAA PAPER 90-4031) Copyright

Consideration is given to the propagation through turbulence of transient pressure waveforms whose initial onset at any given point is an abrupt shock. The work is motivated by the desire to eventually develop a mathematical model for predicting statistical features, such as peak overpressures and spike widths, of sonic booms generated by supersonic aircraft. It is argued that the transient waveform received at points where x greater than 0 will begin with a pressure jump and a formulation is developed for predicting the amount of this jump and the time derivatives of the pressure waveform immediately following the jump. Author

A91-12543*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THE ACOUSTIC RESULTS OF A UNITED TECHOLOGIES SCALE MODEL HELICOPTER ROTOR TESTED AT DNW

SANDY R. LIU (NASA, Ames Research Center; U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and MICHAEL A. MARCOLINI (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 13th, Tallahassee, FL, Oct. 22-24, 1990. 22 p. refs
(AIAA PAPER 90-4035) Copyright

An initial summary is presented of the acoustic measurements acquired for some of the different configurations of a 1/6 geometrically and aeroelastically scaled UTC model helicopter rotor which was tested in the open-jet anechoic test section of the Duits-Nederlandse Windtunnel in the Netherlands. Of particular interest are high-speed impulsive noise and blade-vortex interaction. An analysis is provided of baseline swept tip rotor acoustic characteristics in the regimes of high-speed forward flight, where high-speed impulsive noise dominates, and low-speed descent, where severe blade vortex interaction noise occurs. Also discussed are more recent studies of data which involve the animation of the acoustic field upstream of the rotor to evaluate the detailed radiation patters caused by BVI and HSI noise sources. The trends of these primary noise sources are examined as the first step in validating the data for release and application. L.K.S.

N91-10699*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
HELICOPTER FAR-FIELD ACOUSTIC LEVELS AS A FUNCTION OF REDUCED MAIN-ROTOR ADVANCING BLADE-TIP MACH NUMBER
ARNOLD W. MUELLER, CHARLES D. SMITH, and PHILIP LEMASURIER (Sikorsky Aircraft, Stratford, CT.) Jul. 1990 28 p
(NASA-TM-102684; NAS 1.15:102684) Avail: NTIS HC/MF A03 CSCL 20/1

During the design of a helicopter, the weight, engine, rotor speed, and rotor geometry are given significant attention when considering the specific operations for which the helicopter will be used. However, the noise radiated from the helicopter and its relationship to the design variables is currently not well modeled with only a limited set of full-scale field test data to study. In general, limited field data have shown that reduced main-rotor advancing blade-tip Mach numbers result in reduced far-field noise levels. The status of a recent helicopter noise research project is reviewed. It is designed to provide flight experimental data which may be used to further understand helicopter main-rotor advancing blade-tip Mach number effects on far-field acoustic levels. Preliminary results are presented relative to tests conducted with a Sikorsky S-76A helicopter operating with both the rotor speed and the flight speed as the control variable. The rotor speed was operated within the range of 107 to 90 percent NR at nominal forward speeds of 35, 100, and 155 knots. Author

N91-10703*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AEROACOUSTIC EFFECTS OF REDUCED AFT TIP SPEED AT CONSTANT THRUST FOR A MODEL COUNTERROTATION TURBOPROP AT TAKEOFF CONDITIONS
RICHARD P. WOODWARD and CHRISTOPHER E. HUGHES Oct. 1990 21 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored in part by AIAA
(NASA-TM-103608; E-5732; NAS 1.15:103608; AIAA-90-3933) Avail: NTIS HC/MF A03 CSCL 20/1

A model high-speed, advanced counterrotation propeller, F7/A7, was tested in the anechoic wind tunnel at simulated takeoff and approach conditions of Mach 0.2. The propeller was operated in a baseline configuration with the forward and aft rotor blade setting angles and forward and aft rotational speeds essentially equal. Two additional configurations were tested with the aft rotor at increased blade setting angles and the rotational speed reduced to achieve overall performance similar to that of the baseline configuration. Acoustic data were taken with an axially translating microphone probe that was attached to the tunnel floor. Concurrent aerodynamic data were taken to define propeller operating conditions. Author

N91-10704# Rolls-Royce Ltd., Derby (England).
DO WE REALLY NEED 57 WAYS OF RATING AIRCRAFT NOISE
M. J. T. SMITH 13 Aug. 1990 5 p Presented at the 1990 International Conference on Noise Control Engineering, Goteberg, Sweden, 13-15 Aug. 1990
(PNR-90720; ETN-90-97946) Copyright Avail: NTIS HC/MF A01

The difficulties encountered for measuring and quantifying the effects of aircraft noise are analyzed. The impact of the noise measurement results on the air transport business community is discussed. The common elements between all noise measurements and control methodologies are given. The relationship between absolute level and footprint area of constant noise level is presented. The noise certification standards are determined. ESA

N91-11488*# Duke Univ., Durham, NC. Dept. of Mechanical Engineering and Materials Science.
AIRCRAFT INTERIOR NOISE REDUCTION BY ALTERNATE RESONANCE TUNING Progress Report, period ending June 1990
DONALD B. BLISS, JAMES A. GOTTWALD, RAMAKRISHNA SRINIVASAN, and MARK B. GUSTAVESON Aug. 1990 41 p (Contract NAG1-722)
(NASA-CR-186879; NAS 1.26:186879) Avail: NTIS HC/MF A03 CSCL 20/1

Existing interior noise reduction techniques for aircraft fuselages perform reasonably well at higher frequencies, but are inadequate at lower frequencies, particularly with respect to the low blade passage harmonics with high forcing levels found in propeller aircraft. A method is being studied which considers aircraft fuselage lined with panels alternately tuned to frequencies above and below the frequency that must be attenuated. Adjacent panels would oscillate at equal amplitude, to give equal source strength, but with opposite phase. Provided these adjacent panels are acoustically compact, the resulting cancellation causes the interior acoustic modes to become cutoff, and therefore be non-propagating and evanescent. This interior noise reduction method, called Alternate Resonance Tuning (ART), is currently being investigated both theoretically and experimentally. This new concept has potential application to reducing interior noise due to the propellers in advanced turboprop aircraft as well as for existing aircraft configurations. Author

N91-11493*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
NOISE MEASUREMENTS FROM AN EJECTOR SUPPRESSOR NOZZLE IN THE NASA LEWIS 9- BY 15-FOOT LOW SPEED WIND TUNNEL
EUGENE A. KREJSA, BETH A. COOPER, DAVID G. HALL, and ABBAS KHAVARAN (Sverdrup Technology, Inc., Brook Park, OH.) Oct. 1990 62 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored in part by AIAA
(NASA-TM-103628; E-5717; NAS 1.15:103628; AIAA-90-3983) Avail: NTIS HC/MF A04 CSCL 20/1

Acoustic results are presented of a cooperative nozzle test program between NASA and Pratt and Whitney, conducted in the NASA-Lewis 9 x 15 ft Anechoic Wind Tunnel. The nozzle tested was the P and W Hypermix Nozzle concept, a 2-D lobed mixer nozzle followed by a short ejector section made to promote rapid mixing of the induced ejector nozzle flow. Acoustic and aerodynamic measurements were made to determine the amount of ejector pumping, degree of mixing, and noise reduction achieved. A series of tests were run to verify the acoustic quality of this tunnel. The results indicated that the tunnel test section is reasonably anechoic but that background noise can limit the amount of suppression observed from suppressor nozzles. Also, a possible internal noise was observed in the air supply system. The P and W ejector suppressor nozzle demonstrated the potential of this concept to significantly reduce jet noise. Significant reduction in low frequency noise was achieved by increasing the peak jet

noise frequency. This was accomplished by breaking the jet into segments with smaller dimensions than those of the baseline nozzle. Variations in ejector parameters had little effect on the noise for the geometries and the range of temperatures and pressure ratios tested. Author

N91-11494*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF SWIRL RECOVERY VANES ON THE CRUISE NOISE OF AN ADVANCED PROPELLER
JAMES H. DITTMAR and DAVID G. HALL (Sverdrup Technology, Inc., Brook Park, OH.) 1990 18 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored by AIAA
(NASA-TM-103625; E-5731; NAS 1.15:103625; AIAA-90-3932)
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The SR-7A propeller was acoustically tested with and without downstream swirl recovery vanes to determine if any extra noise was caused by the interaction of the propeller wakes and vortices with these vanes. No additional noise was observed at the cruise condition over the angular range tested. The presence of the swirl recovery vanes did unload the propeller and some small peak noise reductions were observed from lower propeller loading noise. The propeller was also tested alone to investigate the behavior of the peak propeller noise with helical tip Mach number. As observed before on other propellers, the peak noise first rose with helical tip Mach number and then leveled off or decreased at higher helical tip Mach numbers. Detailed pressure-time histories indicate that a portion of the primary pressure pulse is progressively cancelled by a secondary pulse as the helical tip Mach number is increased. This cancellation appears to be responsible for the peak noise behavior at high helical tip Mach numbers. Author

N91-11495*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREDICTION OF THE NOISE FROM A PROPELLER AT ANGLE OF ATTACK
EUGENE A. KREJSA Oct. 1990 22 p Presented at the 13th Aeroacoustics Conference, Tallahassee, FL, 22-24 Oct. 1990; sponsored in part by AIAA
(NASA-TM-103627; E-5795; NAS 1.15:103627; AIAA-90-3954)
Avail: NTIS HC/MF A03 CSCL 20/1

An analysis is presented to predict the noise of a propeller at angle of attack. The analysis is an extension of that reported by Mani which predicted the change in noise due to angle of attack to both unsteady loading and to azimuthal variation of the radiation efficiency of steady noise sources. Mani's analysis, however, was limited to small angles of attack. The analysis reported herein removes this small angle limitation. Results from the analysis are compared with the data of Woodward for a single rotation propeller and a counter rotating propeller. The comparison shows that including the effect of angle of attack on the steady noise sources significantly improves the agreement with data. Including higher order effects of angle of attack, while changing the predicted noise at far forward and aft angles, has little effect near the propeller plane. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A91-10962
ASSESSING THE MARKET FOR HIGH SPEED AIR TRAVEL IN THE 21ST CENTURY
R. W. SIMPSON (MIT, Cambridge, MA) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 113-121. refs
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A review of the mechanistic methods used to produce high speed civil transport (HSCT) fleet forecasts in past years is presented. The economic terms of the market for air travel services and the need for market research studies to estimate the probable fleet size for an HSCT are discussed. It is shown that previous methodologies to predict the HSCT market do not provide reliable procedures for estimating future fleet sizes. Therefore, it will be necessary to perform accurate market research surveys of travel patterns in using subsonic wide body sleeper aircraft, teleconferencing, and HSCT in the future as a guide to forecasting the requirement for high speed commercial transports. R.E.P.

A91-10963
THE HIGH SPEED MARKET IN THE NEXT THREE DECADES
L. DI GIORGIO (Alitalia S.p.A., Rome, Italy) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 127-130.
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The commercial and technological requirements that will be demanded of a supersonic transport program are presented. Predominant efforts will be needed in long range capability, direct operating costs that are comparable to subsonic aircraft, and seating capacity of over 300. Technology is continually being improved to achieve greater benefits in reduced specific fuel consumption and thrust-to-weight ratios to achieve the continuously increasing air transport range requirements. It is concluded that priority in research should be devoted to sonic boom reduction, the ozone depletion problem, reduction of side line noise, supersonic laminar flow control, and materials, components and systems to sustain supersonic cruise at Mach 3. R.E.P.

A91-10970
A CASE STUDY IN FOSTERING INTERNATIONAL HSCT COLLABORATION
JAMES P. LOOMIS and ROBERT F. BESTGEN (Battelle Memorial Institute, Columbus, OH) IN: European Symposium on the Future of High Speed Air Transport, Strasbourg, France, Nov. 6-8, 1989, Proceedings. Toulouse, France, Cepadues-Editions, 1990, p. 231-236.
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The factors that led Battelle to establish its Center for High Speed Commercial Flight, the international inquiry phase, and the conclusions reached are presented. The characteristics and purposes of an international collaboration program that was defined and marketed, and how well this was received, are discussed. U.S. manufacturers, financial institutions, operators, and government institutions were provided with a joint forum as they pursued the possibilities of developing a commercially viable, environmentally acceptable high speed commercial transport. The Center's program and its outcome are described, along with the prospects for international collaboration. R.E.P.

A91-12233#
CONFIGURATION CONTROL AND AIRWORTHINESS MANAGEMENT
YOSHIYUKI FUJITSUNA and KENTARO TAKE Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, July 1990, p. 296-299. In Japanese, with abstract in English.

Based upon V2500-A1 engine development and production experiences, the concept and policy of civil engine configuration control and airworthiness management are described together with actual process and procedure. First of all, in order to help reader' understanding, general program of civil engine development activities is explained. Then, as for development engine configuration control, the essence of the VIZ type design definition is described. On the other hand, production engine configuration control is characterized by 3-staged engineering change management system in addition to substantiation process-similarity,

analysis or test. As for airworthiness management, the legal background is shown and what was done practically in V2500 certification tests is reported. Finally, future target of configuration control and airworthiness management are noted. Author

N91-10931# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
A QUARTER OF A CENTURY OF AEROELASTIC COOPERATION BETWEEN RESEARCH AND INDUSTRY (A REVIEW). PART 1: FIGHTER AIRPLANES AND HELICOPTERS
O. SENSBURG, J. BECKER, H. HOENLINGER, and G. STREHLOW *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 223-270 Apr. 1990
Avail: NTIS HC/MF A13

Tests and developments which enabled the German aircraft industry and the DLR Institute of Aeroelasticity to become competitive again with other leading nations are described. The first steps, the development of the first German vertical takeoff airplane VJ 101 are depicted. The Tornado fighter airplane aeroelastic investigations are reviewed. Developments and tests for the introduction of active control technology into aircraft design are described. The research work for the European fighter aircraft is outlined. Helicopter aeroelasticity investigations are presented. ESA

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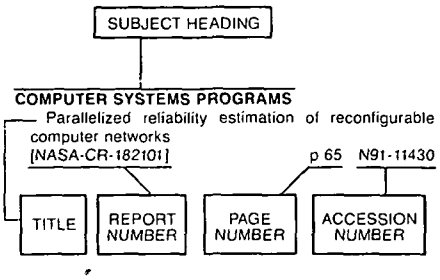

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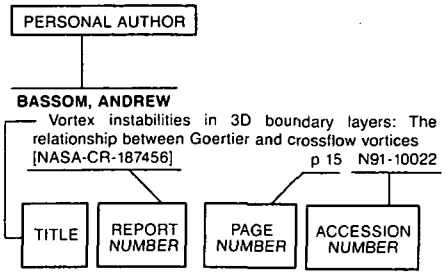

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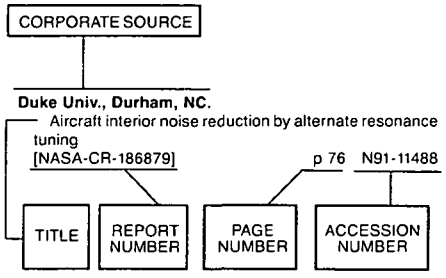

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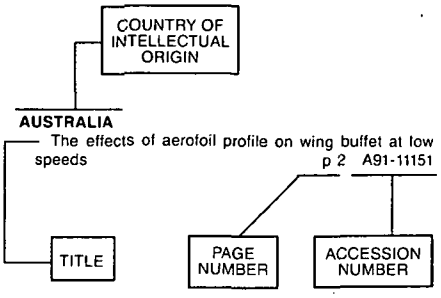

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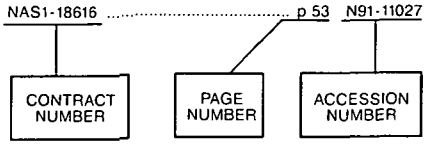

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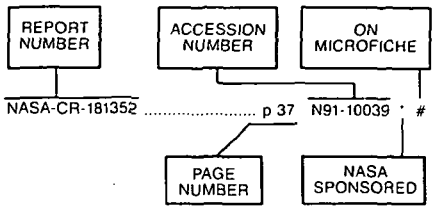

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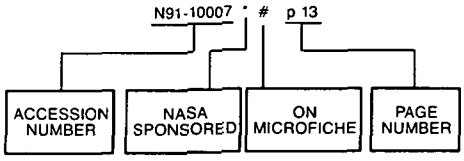

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